The Energy Factbook:

A Resource For South Carolina

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Education Resources

Provided by the South Carolina Energy Office and the S.C. Department of Health and Environmental Control

- **"Action for a cleaner tomorrow: A South Carolina Environmental Curriculum Supplement:"** This kindergarten through 12th grade curriculum supplement includes 12 energy lessons that provide not only a global and national perspective on energy, but South Carolina-specific information as well. Teachers can receive a printed copy or CD-ROM of "Action" following a mandatory three-hour workshop. Both the curriculum and workshop are free.
- **E2IQ Kit:** This energy-only kit is tailored to the grade level of the requesting teacher. Along with energy posters, lessons, games and promotional items, the E2IQ Kit contains information on how to set up a school-wide Energy Patrol (elementary), participate in energy activities (sixth grade) and information on submitting science fair projects to the S.C. Junior Academy of Science (ninth and 10th grade).
- **Energy Glossary**
- **"Science Fair Project Guidebook: A Resource for Students and Teachers"** is a hands-on guidebook that covers the basics from how to choose a science fair topic to the final exhibit. The guidebook, applicable for students of all ages and their parents, also contains science fair projects on energy. For your free copy of "The Science Fair Project Guidebook," call the S.C. Energy Office at **1-800-851-8899** or **(803) 737-8035**. The guidebook also is available on-line at **www.energy.sc.gov/k-12educationpage.htm**.
- **Recycling Resource Center**
- **National Energy Education Development Project:** The National Energy Education Development Project, NEED, is a nationally recognized energy education program dedicated to developing innovative educational materials and training programs for teachers and students.
- **AND MUCH, MUCH MORE!**

*Call **1-800-768-7348** or **1-800-851-8899** for details.*

Web Sites of Interest

Listed below are the Web site sponsors, titles and Internet addresses for various energy-related Web sites.

Alliance to Save Energy, Multidisciplinary Lesson Plans
www.ase.org/educators/index.htm

America Recycles Day, www.americarecyclesday.org

Energy Center of Wisconsin, Energy Ed On-line
www.uwsp.edu/cnr/wcee/keep

Energy Efficiency and Renewable Energy,
Energy Education Page
http://www.eere.energy.gov/education/

Energy Efficiency and Renewable Energy Network (EREN), Kids' Stuff
http://www.eren.doe.gov/kids

Energy Information Association, Kid's Page
http://www.eia.doe.gov/kids/

U.S. Environmental Protection Agency, Explorers' Club
www.epa.gov/kids

National Energy Education Development Project (NEED)
www.need.org

Newton's Apple, Electric Cars
www.ktca.org/newtons/10/electricar.html

Newton's Apple, Electricity
www.ktca.org/newtons/12/electric.html

Newton's Apple, Ethanol
www.ktca.org/newtons/14/ethanol12.html

Newton's Apple, Sun
www.ktca.org/newtons/12/sun.html

S.C. Department of Health and Environmental Control
www.scdhec.gov/recycle

S.C. Energy Office
www.energy.sc.gov

Tennessee Energy Education Network, TEEN On-line
http://www.tnenergy.com/

U.S. Department of Energy, Kidszone
http://www.energy.gov/kidz/kidzone.html

Chapter 1

An Introduction To Energy

What is energy?

Energy is what makes things work. When we flip on a light switch, we use energy. We use energy riding a bus to school. Listening to a favorite song on a CD player uses energy. Try to imagine a world without energy. There would be no TV, no computers and no cars. Energy is what makes our lives comfortable and prosperous.

Where does energy come from?

A major source of energy is the sun. The sun's light and heat are both forms of energy. Plants use the sun's energy to grow. When we eat plants, we take in their energy. This gives us the energy to think and learn. It also gives us muscle power.

Wind and water also are energy sources. So too are oil, coal, natural gas and things that grow. You may be familiar with nuclear energy, as well. Nuclear energy, produce from uranium (a mineral found in the ground), is popularly used in South Carolina to produce electricity, another form of energy.

Energy's Role in History

Because energy is basic to our lives, it is at the very heart of civilization. Prehistoric people learned to use fire's heat energy. They used it to take away the night's chill, to cook food and to fashion tools.

The ancient Egyptians discovered there was energy in wind. They used it to sail their ships. By the first century B.C., people had learned to use the energy power of water. The water wheel harnessed the energy of moving water. Water power was stronger than the muscle power of both people and animals combined.

The principle behind the water wheel was also applied to wind. Windmills popped up in the lowlands of Europe. Using only the wind for power, windmills ground grains into flour. In areas far from the seas, wind power became an important energy resource.

By the 1800s, civilization searched for more energy resources. People, work animals (such as horses and oxen) and wood were no longer enough. While water and wind power continued to fill many energy needs, they were unreliable.

The answer to this quest came in the form of James Watt's invention of the steam engine.

Steam, produced from burning wood or coal, took industry indoors. Workers left their rural homes for work in big city factories. The Industrial Revolution pushed civilization "full steam" ahead.

Other energy inventions followed. One exciting idea seemed to spark another. Work by physicists in Europe and experiments by Thomas Edison in New Jersey led to the invention of the light bulb in 1879. By 1882, New York's Pearl Street generator was routinely sending electricity into homes.

Pictured above: *Thomas Edison's electric light bulb.*

Our Changing Energy Needs

Inventions and industrialization also changed our energy needs. In Colonial times, wood was the chief fuel used in the U.S. By the 1850s, wood was still filling 90 percent of our energy requirements. Coal was also becoming an important fuel, since it powered the steam engines that ran factories.

Growing Strong With Energy

All of this changed in 1859 with the invention of the internal combustion engine. The gasoline-driven, fossil fuel-burning internal combustion engine became the foundation for the "horseless carriage." Cars transformed American society forever. Their huge popularity made gasoline the driving energy force in our economy.

For the first two-thirds of the 20th century, America was the undisputed technological king of the world. Our prospering economy, even after two World Wars, was built on our many energy resources. Americans consumed petroleum, natural gas, coal and wood with confidence that these resources would not run out. Nuclear energy also became an important resource. Americans were unmatched in their ability to use energy of all types. By 1970, 210 million Americans used more energy just for air conditioning alone than the 800 million people in China used to fill all of their energy needs.

The Oil Crisis of 1973

Then came the Oil Crisis of 1973. Politics suddenly controlled energy resources. Because the U.S. politically supported Israel, the oil-rich Arab countries stopped selling us oil. Everyone felt the impact of the oil shortage. We had become so used to using oil to run our cars and heat our homes and generate our electricity, we hardly knew how to get through our daily lives without it. Airlines cut back on flights. Vacations were canceled. Administrators thought about shortening the school year. Workers lost jobs. For the first time, people stopped taking energy for granted.

Our Energy Future

Fortunately, that crisis ended in 1974. Perhaps even more fortunately, we learned important lessons. We then knew our energy supplies were not limitless. Petroleum, in particular, will not always be plentiful and inexpensive.

In response, we have developed technologies that make better use of our resources. Appliances and homes have become more energy efficient. Scientists have also looked to previously untapped resources as alternative energy sources, like the use of waste products for fuels.

The Oil Crisis of 1973 taught us to rethink the way we use energy. While energy use is still considered a sign of progress, energy waste is now regarded as both shortsighted and thoughtless. Through conservation, we can lessen our dependence on foreign suppliers of energy, and prolong the life of those resources we have.

In South Carolina, these lessons have been put into action. You have an opportunity in “The Energy Factbook” to explore the world of energy in depth. Energy is something we must think about today and plan for tomorrow. It concerns us all.

An Energy Time Line

- **4.5 billion years ago** — Solar energy reaches the earth.
- **1st century B.C.** — Water wheels harness the power of moving water.
- **5th century A.D.** — Windmills are first used in Persia.
- **1807** — James Watt’s steam engine ushers in the Industrial Revolution.
- **1859** — First oil well is built in the U.S.
- **1859** — Jean Lenoir invents the internal combustion engine.
- **1879** — Thomas Alva Edison invents the light bulb and lights up the world.
- **1893** — Henry Ford builds his first “horseless carriage” – the automobile.
- **1903** — Wright Brothers fly a gasoline-powered airplane.
- **1942** — U.S. Scientist Enrico Fermi engineers a nuclear reaction.
- **1952** — Solar cells are invented.
- **1973** — Worldwide oil crisis occurs.
- **1977** — U.S. Department of Energy created.
- **1979** — Three Mile Island nuclear accident occurs.
- **1980** — First U.S. wind farm built.
- **1986** — World’s worst nuclear accident to date happened at the Chernobyl reactor complex in the former Soviet Union.
- **1990** — Iraq invades oil-rich Kuwait, creating major international crisis.
- **1998** — California opens the deregulated electricity market.
- **2000** — “Rolling blackouts” plague California and Nevada.
- **2003** — The Blackout of 2003 darkens the northeastern United States and parts of Midwest and Canada, affecting 50 million people and causing more than $1 billion in damages.

ENERGY MEASUREMENT EQUIVALENTS

1 ton	2,000 pounds
1 barrel (oil)	42 gallons, or 5.6 cubic feet
1 Watt (W)	A metric unit of electrical power; the product of voltage and current
1,000 Watts	1 kilowatt (kW)
1,000 kilowatts	1 megawatt (mW)
1 kilowatt hour (kWh)	1000 watts of power used for one hour of time; equals 3,413 Btu
1,000 kilowatt hours	1 megawatt hour (mWh)
1 quad	one quadrillion Btu
1 Btu	Quantity of heat required to raise the temperature of one pound of water by one degree Fahrenheit.
1,000 Btu	1 kBtu
1 therm (natural gas)	100,000 Btu
1 Ccf (100 cubic feet – natural gas)	1.03 therms
1 Mcf (1,000 cubic feet – natural gas)	1,030,000 Btu
1 gallon	3.785 liters
1 MMBtu	1,000,000 Btu

ENERGY CONVERSION STATISTICS

Carbon dioxide emissions for 1 kWh	1.5 pounds
Coal required to produce 1 kWh	1 pound
Average U.S. cost of 1 kWh	6.64 cents
Average annual gallons of gasoline used per car	500 gallons
Average annual heat savings using 1 low-flow shower head	466 kWh

BTU CONVERSION FACTORS

FUEL TYPE	BTU
Electricity (kilowatt hours)	11,600
Fuel Oil (No. 2) – gallon (diesel fuel, home heating oil)	138,400
Fuel Oil (No. 6) – gallon (industrial heating oil)	153,600
LPG (liquefied petroleum gas – propane)	95,475
Coal (ton)	24,500,000
1 kilowatt hour	11,000
1 barrel of oil	6,250,000

Chapter 2

The Energy Basics

Before going any further, you may find it helpful to review some essential energy concepts. Knowing these will help you better understand energy.

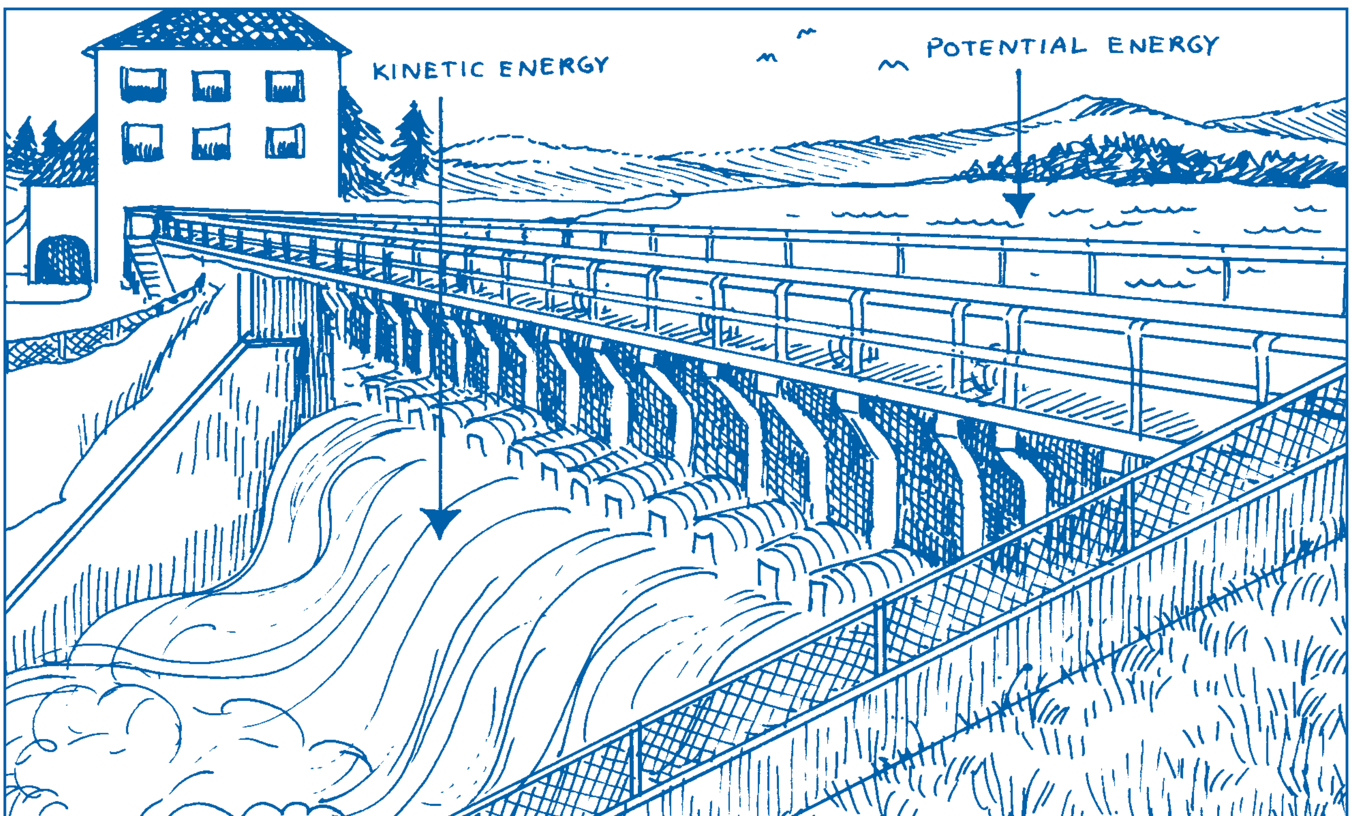
Types of Energy

There are two types of energy: (1) *potential* or stored energy and (2) *kinetic* energy or energy in motion. As you can tell from the diagram, potential energy, such as that found in lake water, is energy which is not yet in use, but which may be trapped. Kinetic energy is energy in motion, such as a waterfall. Electricity produced by running water is also kinetic energy.

Energy can change from one type to another, as the water does in the diagram. When energy changes states (such as from potential to kinetic), energy is neither lost nor created. This is what is known as the *Law of the Conservation of Energy*. According to this principle, energy cannot be made or destroyed. It can only be changed from one type to another.

Forms of Energy

In addition to changing states, energy can change into different forms. Once again, no energy is created and no energy is lost in the process. For example, when sunlight passes



Potential and Kinetic Energy

through the rolled up windows of a car, it becomes trapped inside as heat energy. Similarly, the heat from burning coal can be used to change water into steam. One form of energy turns into another form. The steam can then be used to generate yet another form of energy, electricity.

There are several basic forms of energy. Light, either from the sun or a lamp, is known as *radiant energy. Gravitational energy* is the earth's pull. *Chemical energy* refers to such things as the carbohydrates found in food or the methane in natural gas. All fuels have chemical energy in them. *Thermal energy* involves heat. All objects have thermal energy when they are hot. *Mechanical energy* is stored in the moving parts of machines. *Electrical energy* is found in charged objects. *Nuclear energy* comes from radioactive elements.

Measuring Energy

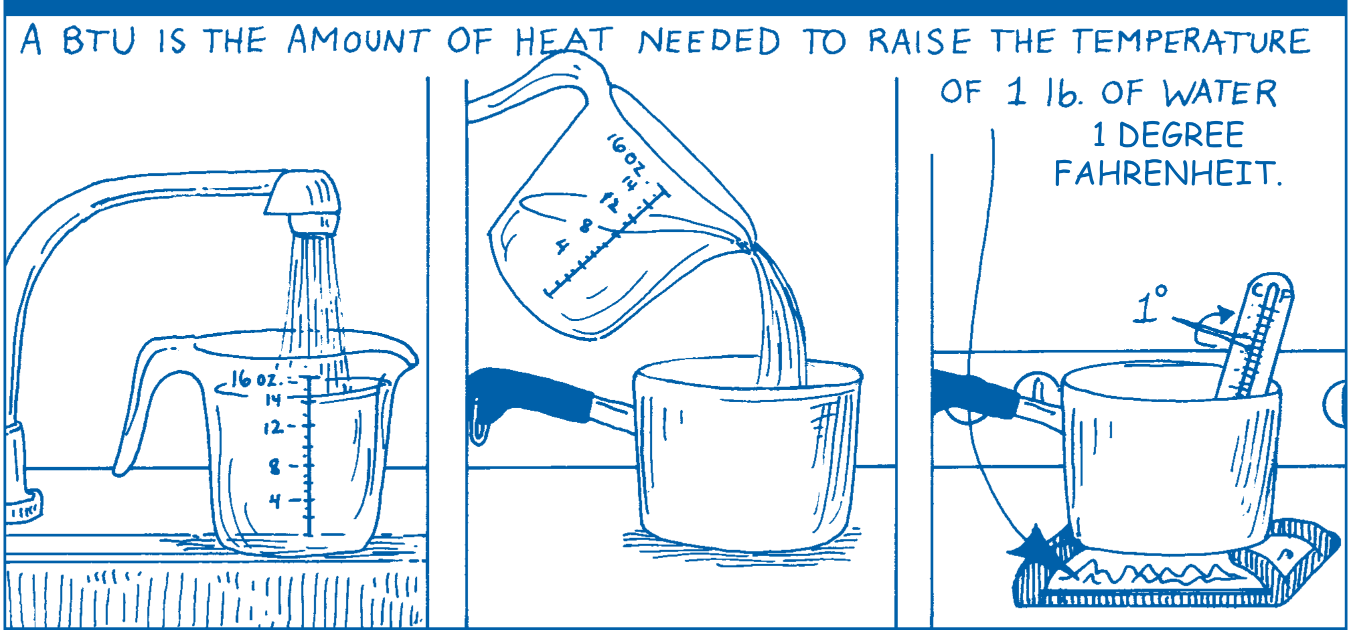
To measure energy, we determine the amount of heat energy being produced. This is done by using a measure known as a British thermal unit or Btu. The scientific definition of a Btu, as illustrated in the diagram below, is the amount of heat needed to raise the temperature of one pound of water one degree Fahrenheit. The U.S. Energy Information Administration (EIA) operationally defines this as the amount of heat given off by one blue-tip kitchen match.

Btus become very helpful when trying to compare one fuel source with another. This is because energy comes in a variety of forms. Each form is measured in terms convenient to that state. For example, we measure natural gas in terms of its volume. Oil, which is a liquid, is measured in terms of barrels filled. Solid lumps of coal are weighed in tons. To be able to compare these different types of fuels, we need a common measure. This is where the Btu comes in. It allows us to compare energy in a variety of fuels that are measured differently.

Energy Use

In looking at energy use, it's also helpful to think of how it is used. Energy analysts commonly think about energy use in terms of groups or *sectors* of the economy. As shown in the illustrations on the following page, these four sectors are the residential, commercial, industrial and transportation sectors.

What is a BTU?



The *residential sector* refers to private home usage of energy. “Homes” include single and attached family houses and townhouses, apartments, co-ops and condominiums, farmhouses and mobile homes. In this sector, people use energy for heating and cooling homes, running appliances, and heating swimming pools.

Schools, hospitals, hotels and motels, retail stores, movie complexes and theaters, and offices make up the *commercial sector*. Here, people use energy for heating and cooling, as well as running business equipment such as computers, cash registers and the like.

Manufacturers, miners, farmers, foresters and fisherman together form the *industrial sector*. Their energy needs are usually large, but can be quite small. They center on operating the machinery that runs our nation’s factories and mills.

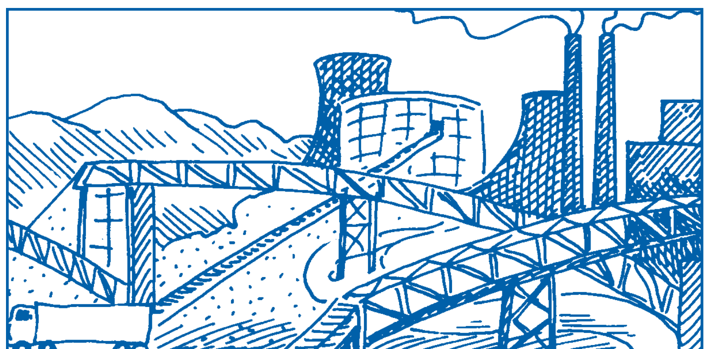
The *transportation sector* includes the cars, trucks, buses and motorcycles that run on our nation’s highways. This sector also includes ships, trains, airplanes and helicopters. The energy needs for this sector are almost entirely for operating fuel.

Conclusion

Being familiar with these basic concepts and terms will enhance your understanding of energy. Whether you use “The Energy Factbook” as a reference tool or for reading pleasure, it is yours to learn from and enjoy.

Residential

Commercial



Industrial

Transportation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Chapter 3

South Carolina's Energy Situation

South Carolina is a growing state. As our economy has developed, so too have our energy needs. In the last several decades, only four states have had higher energy use rates than we in South Carolina have had.

How do we use energy?

While we use energy in every sector of the economy, industry uses the most. It takes large supplies of energy to run the mills, factories and farms that make our state prosper. Industry accounts for 41.4 percent of the state's energy use.

The transportation sector is the second largest user of energy. Being primarily a rural state, this is not surprising. We are, by necessity, a state of drivers. People in South Carolina travel extended distances to get where they need to go. It takes nearly two billion gallons of gasoline a year to keep South Carolinians on the move!

We use less energy in our homes. Almost 19.5 percent of the energy used in South Carolina serves to heat and cool residences, run appliances and heat swimming pools.

The commercial sector uses the least amount of energy. While this is true in most of the 50 states, South Carolina's commercial sector uses proportionately even less. Only 14 percent of the state's energy is used by businesses, schools and hospitals.

The charts shown on the following page illustrate how South Carolinians use energy in each of the four sectors of the economy.

South Carolina's Current Energy Picture

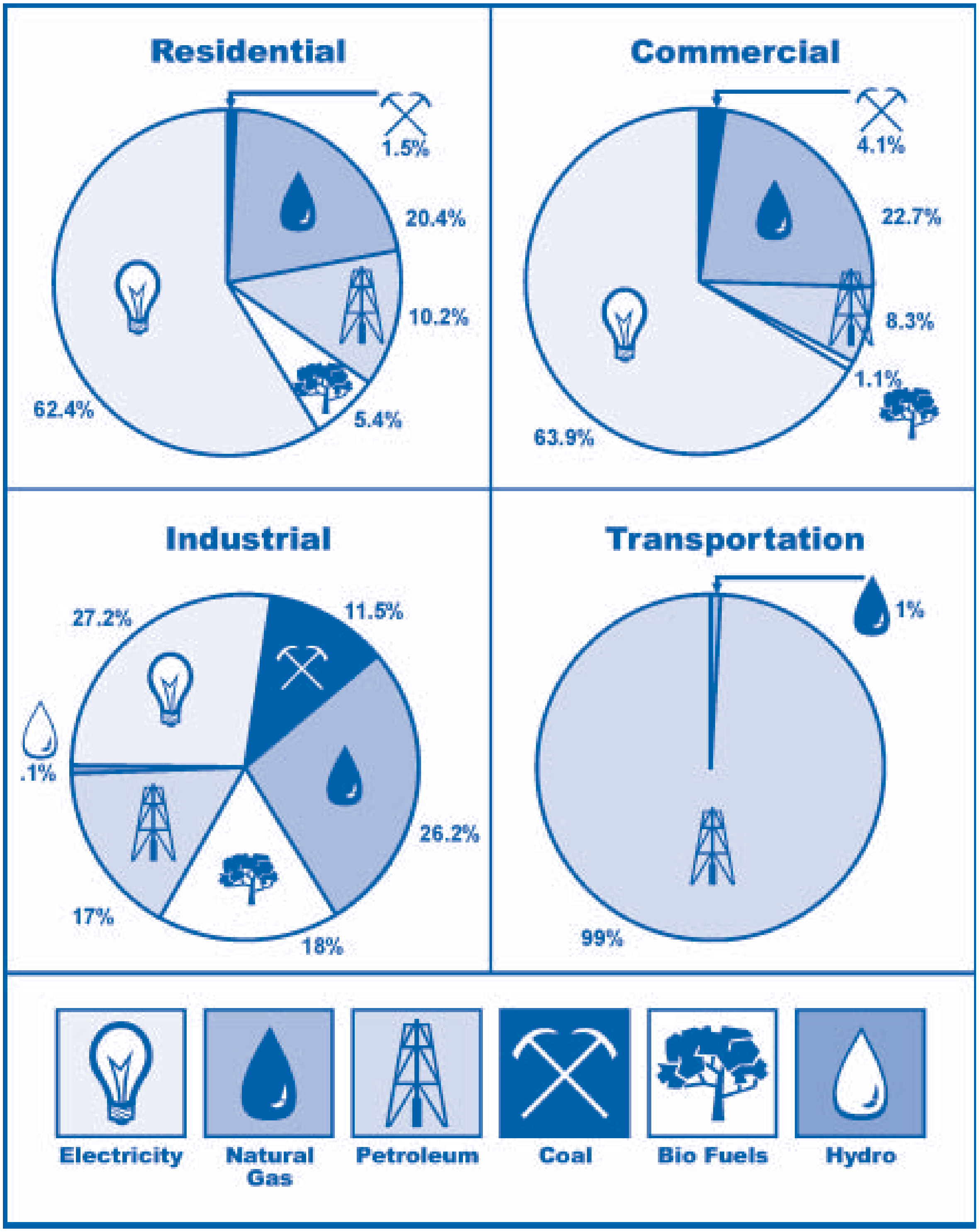
Now that you know how energy is used in our state, you may wonder what energy resources we have. Unfortunately, the answer is not encouraging. South Carolina does not have any conventional energy resources of its own. The oil, coal, natural gas and uranium that make our economy grow must be imported from other states and countries. This carries a heavy price. It costs great sums of money to pay for the energy we need and use.

Our energy outlook, however, is far from dim. While we can't do anything about our lack of fossil fuels and uranium, we can do something to make us less dependent on expensive, imported fuels. With this in mind, state officials and citizens alike are actively seeking ways to improve our energy situation.

Through science and conservation, we are now using proportionally less fossil fuels. About 37 percent of the state's energy needs are met by energy resources other than fossil fuels, much better than the national average of 14.4 percent.

In the remaining chapters of "The Energy Factbook," you'll be able to read about the exciting advances being made in South Carolina. These include experiments with new fuels as well as widespread use of nuclear energy. South Carolina is diligently looking for ways to make its energy future a bright one.

South Carolina's Net Energy Consumption by Sector



SOURCE: *2001 South Carolina Energy Use Profile*

Chapter 4

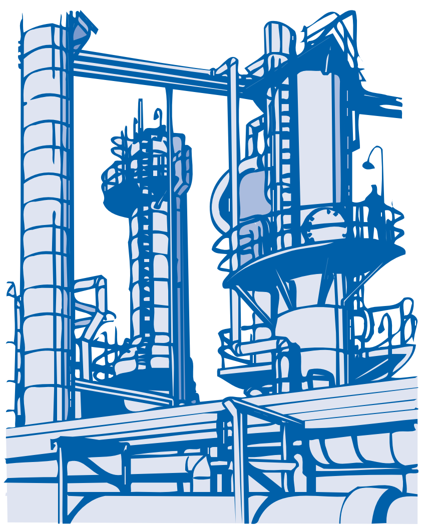
Fossil Fuels: Petroleum, Natural Gas and Coal

How did fossil fuels get their name?

Petroleum, natural gas and coal are known as fossil fuels. They got this name because rocks where these fuels are found often contain imprints of ancient plants and animals known as fossils. When we mine coal and drill for petroleum and natural gas, we are reminded that these energy resources are a part of history.

The Nature of Fossil Fuels

Two features distinguish fossil fuels. First, they are *organic*. This means they originally came from living things. Nature slowly turns plant and animal remains into the fuels we know as petroleum, natural gas and coal.



Second, fossil fuels are *nonrenewable*. By this we mean that supplies are limited. Once the fossil fuels we now have are used up, we will not be able to quickly obtain more.

You may be wondering if the plants and animals around today can be used to form new petroleum, natural gas and coal? In fact, they can. However, the process of forming these fuels takes millions of years. During our lifetime, our energy needs will have to be met by those fossil fuels we already have at hand.

The Role of Fossil Fuels in American Life

Realizing that our supplies of fossil fuels are limited should make us all stop and think. We are a nation of fossil fuel users. Fossil fuels run our cars and planes. They operate our factories and mills. They are used to cook much of our food and heat many of our homes. Fossil fuels provide 85.6 percent of all the energy used in the U.S. Without fossil fuels, the American way of life would not exist as it does today.

In South Carolina, we use somewhat less fossil fuels than the nation as a whole. Still, nearly two-thirds of our energy needs are provided by fossil fuels. Moreover, since no fossil fuels are found here, they have to be brought into the state. This adds to the cost of fossil fuels in South Carolina.

Petroleum

Petroleum is the world's most popular energy resource. In the U.S., petroleum alone accounts for nearly half of the energy we use. It is in such high demand it is known as "black gold."

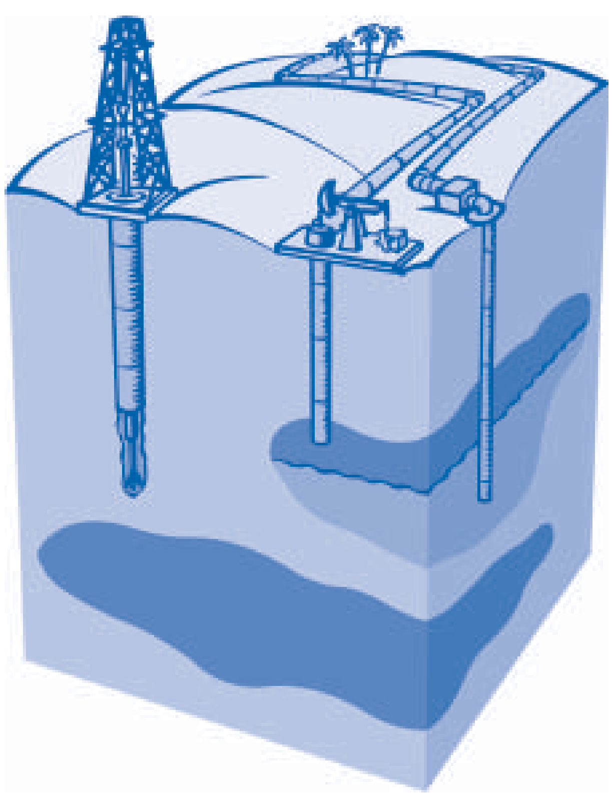
How We Get Petroleum

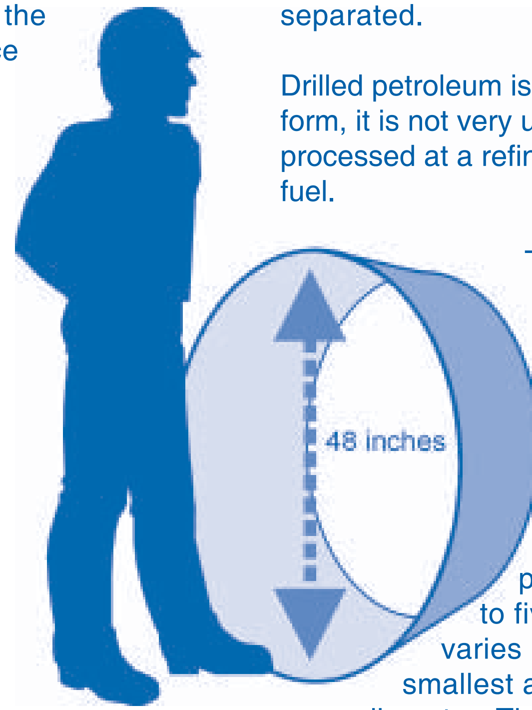
Like all fossil fuels, petroleum began as living matter. It is formed from the remains of tiny sea plants and animals known as plankton. Millions of years ago, plankton settled to the bottom of shallow seas. Sand and mud covered the decaying plankton. Pressure and heat slowly turned the plankton into the hydrogen and carbon substance we know as petroleum.

Most petroleum is found deep below the earth's surface. To reach it, sophisticated drilling procedures are used. First, a test well is drilled to make sure oil is present. If oil is found, a drilling rig is then set up. Tall derricks, like the one shown below, contain drilling equipment.

Petroleum can also be found beneath the ocean floor. If waters are shallow, a rig is set up on a platform that rests on the ocean bottom. In the open sea, floating rigs are built.

Despite the way it may look on TV or in the movies, drilling is a complex procedure. Water and natural gas are brought to the surface along with petroleum. The water must be removed. Natural gas and petroleum need to be separated.





Drilled petroleum is known as *crude oil*. In this form, it is not very useful. The crude oil must be processed at a refinery before it can be used as fuel.

To transport petroleum from the drilling areas to refineries, tankers or pipelines are used. Tankers carry petroleum across oceans. Pipelines move it over land.

Pipelines are built to move petroleum at a speed of three to five miles an hour. Their size varies according to need. The smallest are only two inches in diameter. The largest, such as the Trans-Alaskan pipeline, are 48 inches across. To give you a better idea of size, the drawing above shows a person next to a pipeline that is the same diameter as the Trans-Alaskan pipeline.

At the refinery, crude oil is *distilled*, or boiled. This separates it into a number of energy fuels: gasoline, jet fuel, heating fuel, diesel fuel and kerosene.

A small amount of crude oil is used to produce non-energy related materials known as *petrochemicals*. These chemical materials are used in making many familiar products. Does it surprise you that paint, vitamins and camera film are all made from petroleum?

The distilled petroleum fuels are once more moved out of the refineries by pipelines. Large customers may have fuels piped directly to them. Typically, the fuel is piped to storage areas known as *bulk terminals*. Trucks and railway cars then carry the fuel to oil dealers and gasoline service stations, from whom consumers purchase the fuels they need.

South Carolina's Petroleum Supply

Most petroleum in the U.S. is found in the states of Alaska, Oklahoma, Texas, and Louisiana. Twenty-seven other states also produce petroleum. South Carolina is not among these oil-rich states.

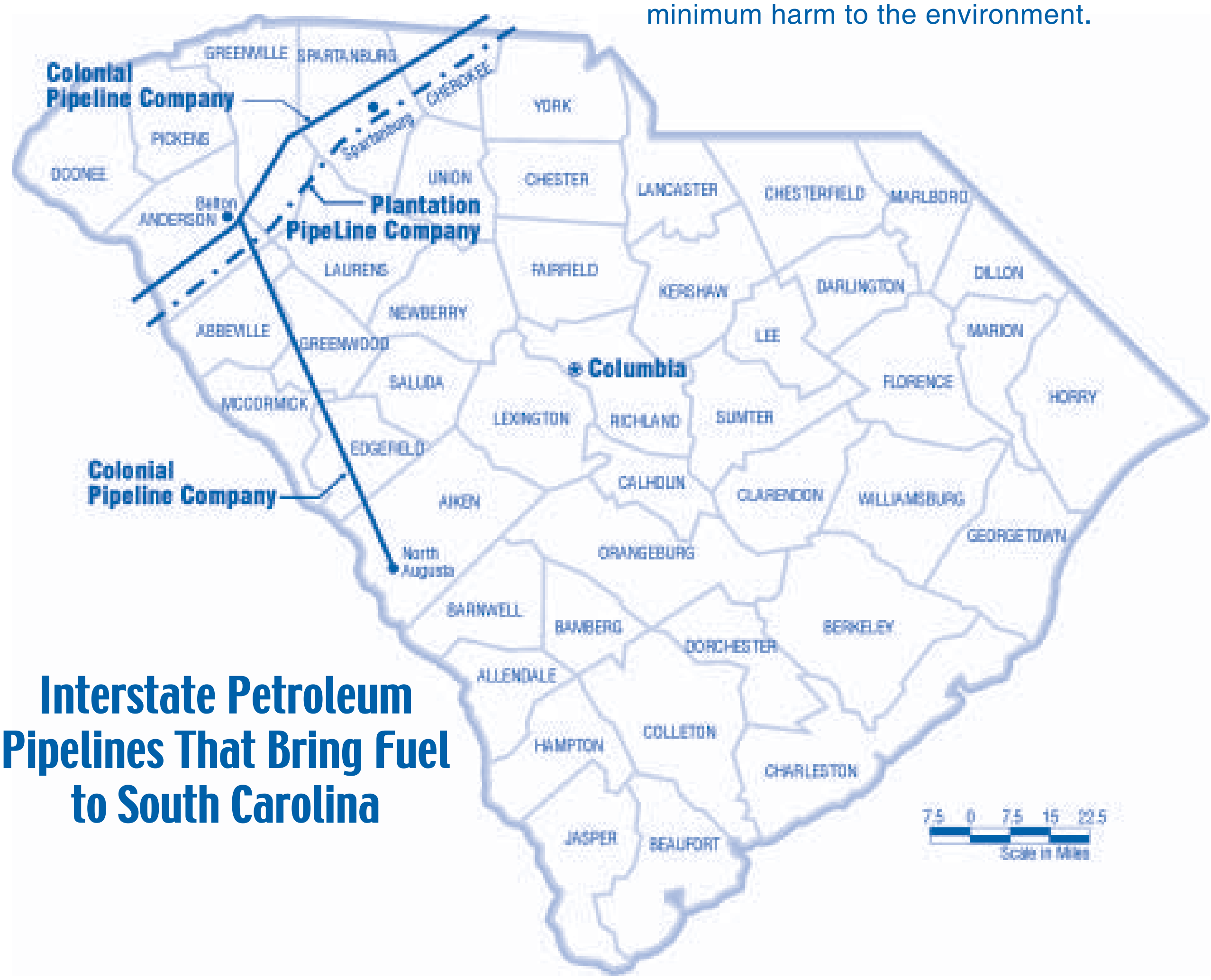
Even though 31 of the 50 states produce some crude oil, 54 percent of the oil used in the United States comes from foreign countries. Much of this imported oil comes to the United States from the Middle East.

Like the rest of the Eastern seaboard, South Carolina imports most of its crude oil from overseas. The crude oil is brought to refineries on the Gulf Coast before being transported to the United States. Two major pipeline companies, the Colonial Pipeline Company and the Plantation Pipeline Company, transport petroleum directly to us. The map below shows the routes traveled by their mostly underground pipelines. Belton and Spartanburg are the main terminal points for both the Colonial and the Plantation pipelines. Colonial also has a marketing terminal in North Augusta. From these cities, petroleum is delivered by truck throughout the state.

Natural Gas

Its Advantages and Disadvantages

Many energy experts believe natural gas is close to being a perfect fuel. Its chief advantage is that it is easy to use. Unlike crude oil which must be distilled, natural gas does not have to be refined. Moreover, burning natural gas does minimum harm to the environment.



Interstate Petroleum Pipelines That Bring Fuel to South Carolina

What, then, is the downside? The primary disadvantage is its scarcity. Natural gas is the least abundant of the fossil fuels.

Unfortunately, in the haste to obtain petroleum, drillers previously burned the natural gas that came to the surface with petroleum. Not knowing it would one day be valuable, it was thought to be less costly to burn the gas than to keep it. Today drillers know otherwise. They now capture the natural gas as it rises through the well to the ground's surface.

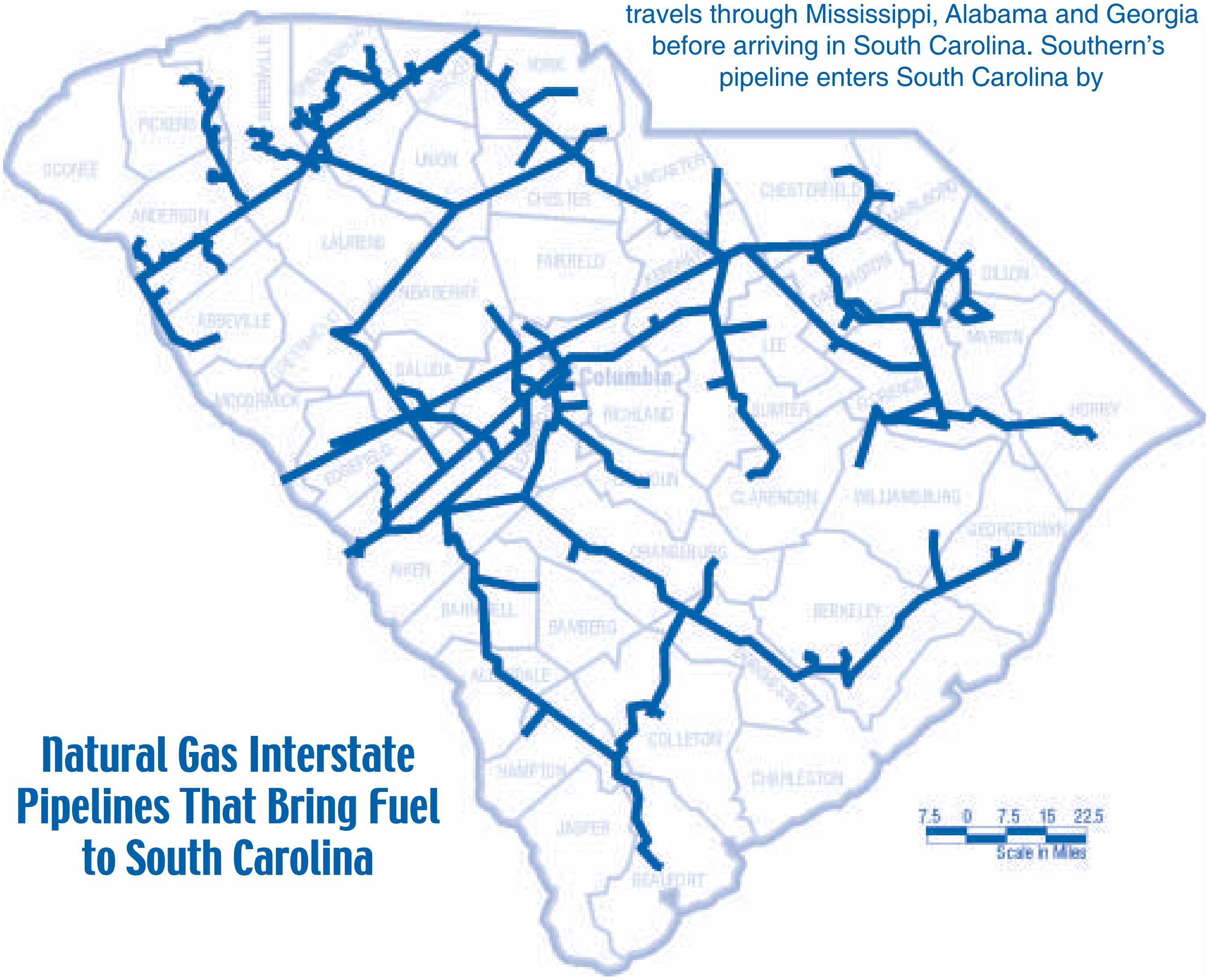
How We Get Natural Gas

Natural gas is carried away from drilling sites by large pipelines. The first natural gas pipelines used in the United States in the early 19th century were made of hollowed logs. Eventually, these were replaced by the steel and cast iron pipes used today.

Most of the natural gas used in South Carolina comes from reserves in Texas, Louisiana and the Gulf of Mexico. It is brought into the state by two major companies – the Transcontinental Gas Pipeline Company (TRANSCO) and the Southern Natural Gas Company. The map below shows where these pipelines enter the state.

The TRANSCO pipeline originates in Texas and runs through Louisiana, Mississippi, Alabama and Georgia before it reaches customers in South Carolina. Although the pipeline cannot be seen from the highway, its route parallels Interstate 85. The pipeline enters the state in Anderson County and runs for nearly 100 miles across the northwest corner of the state. The line then runs through North Carolina, Virginia, Maryland, Delaware and New Jersey before it ends in Pennsylvania.

The Southern pipeline begins in Louisiana and travels through Mississippi, Alabama and Georgia before arriving in South Carolina. Southern's pipeline enters South Carolina by



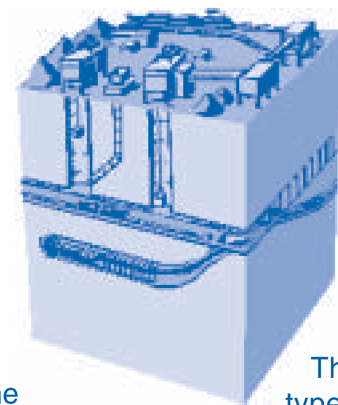
Natural Gas Interstate Pipelines That Bring Fuel to South Carolina

crossing the Savannah River near Augusta, Georgia and ends its route in Aiken.

The natural gas brought here by both TRANSCO and Southern is distributed locally by the S.C. Pipeline Corporation. More than 2,500 miles of S.C. Pipeline Corporation transmission pipelines crisscross the state, delivering natural gas to retail companies. The retailers then sell the natural gas to businesses and home customers through small distribution pipelines.

How We Use Natural Gas

Natural gas is made up almost entirely of methane. Methane is an odorless, tasteless, colorless gas. Natural gas companies add a chemical known as mercaptan – which has an unpleasant odor – to natural gas so it can be detected if there is a gas leak.



Despite being scarce, natural gas is the second most widely used energy resource. In the United States, it meets more than 25 percent of all energy needs. In South Carolina, however, natural gas usage has declined since its peak years in the early 1970s, accounting for 20.4 percent of energy consumption. Natural gas is used to cook food, dry clothes and heat water in more than 50 million American homes. Businesses and industries – ranging from restaurants to steel plants – also use natural gas to fuel their operations. Utilities burn natural gas to generate electricity.

Like petroleum, natural gas is an important fossil fuel in South Carolina's energy picture.

Coal

Coal was once the most important of all the fossil fuels. Until World War II, coal supplied about 67 percent of the nation's energy needs. It was used to warm homes, fuel trains and operate factories.

With America's growing love for the automobile, petroleum replaced steam from burning coal as our fuel of choice for transportation. Other fuels also proved to be more useful for heating and cooling. Today, coal supplies slightly less than 25 percent of U.S. energy needs – the majority of which is used in power plants to produce electricity.

What is coal?

Coal began as swamp plants living 350 million years ago. As giant ferns and mosses died and started to decay, they fell to the bottom of marshes. Eventually they formed peat – fuel that looks much like rotten wood.

Over time, heat and pressure turned peat into coal. Geologists estimate it took a layer of swamp plants 20 feet thick to form a one-foot seam of coal.

Types of Coal

There are four basic types of coal. Each type of coal corresponds to a "grade." Grades represent the amount of carbon in coal. The higher the grade, the more carbon. And the more carbon, the greater the energy in the coal.

The top grade of coal is *anthracite*. *Bituminous* coal is the second highest grade. *Subbituminous* coal, having less carbon, is a lower grade of coal than bituminous. Least rich in carbon and energy is *lignite* coal.

Where is coal found?

Coal is found throughout the world. Russia, China, Australia, India and Indonesia are especially rich with coal reserves. So too is the United States. The National Energy Foundation estimates that there may be 4 trillion tons of coal in the United States.

The vast majority of coal found in the United States is bituminous coal. Wyoming, West Virginia and Kentucky are the leading producers of bituminous coal. The only anthracite coal is in Pennsylvania. Although 36 states have some coal reserves, South Carolina does not.

How do we get coal?

Because coal is found in solid form, it must be mined rather than drilled like petroleum and natural gas. Coal is mined in two ways. Underground, or deep mining, is the traditional way of bringing coal to the surface. It is used primarily in the East. Typically, in this method, *continuous mining machines* are used to dig out the coal.

Strip, or surface mining, is the second way in which coal can be mined. Today, it is the most popular way to mine coal. In this type of mining, huge loading shovels are used to remove a layer of rock and soil known as the *overburden*. Once the overburden is removed, miners are then free to remove the exposed coal. Strip mining can only be done when the coal is buried close to the earth's surface. These types of coal reserves exist chiefly in the Western states.

Concerns for the Environment

Over time, we have learned that mining carries with it environmental responsibilities. Wastes from underground mining can pollute waters. The digging of mines can make land sink or shift. When this happens, nearby roads, sewers and buildings can collapse. Strip mining also removes ground water. This can cause wells to dry up and affects the animals and plants living in the area.

Using coal raises other concerns. Burning coal can pollute the atmosphere. Two major threats to our environment — acid rain[1] and global warming[2] — are thought to be aggravated by burning coal.

To combat these threats to the environment, a number of federal laws have been passed. Strip mines, for example, by law, must be returned to their original condition. Moreover, since 1970, the Clean Air Act (and all its amendments) has required heavy coal users to lower their levels of pollution. By installing scrubbers, industrial plants and public utilities have dramatically lowered the levels of sulfur released by burning coal. In addition, new sources of low sulfur coal have been located for use by industry and utilities. Pollution has been further held in check by the use of precipitators that remove polluting fly ash from the air. Like sulfur, fly ash is released into the atmosphere by burning coal. By reducing both sulfur and fly ash, the environment is made cleaner.

How We Use Coal

The chief use of coal today is in the production of electricity. In South Carolina, more than 42 percent of all the electrical plants are operated by coal, as compared to more than 56 percent in the United States. Many South Carolina industries also use coal to run factories. Very small amounts of coal are used by South Carolina's residential and commercial sectors. The transportation sector, however, stopped using coal in 1977. The coal-fired locomotive is now a relic of our past.

Conclusion

Fossil fuels are very much a part of our energy lives. Although South Carolina is somewhat less dependent on fossil fuels than other states, the state still relies on petroleum, natural gas and coal to meet most of our energy needs.

Since fossil fuel supplies are limited, future energy needs should be considered now. What can Americans do to ensure that the nation has the energy it needs? Two strategies offer hope. First, we can learn to not waste energy. Second, we can look for ways to replace fossil fuels with other resources. America's energy future rests on being wise consumers.

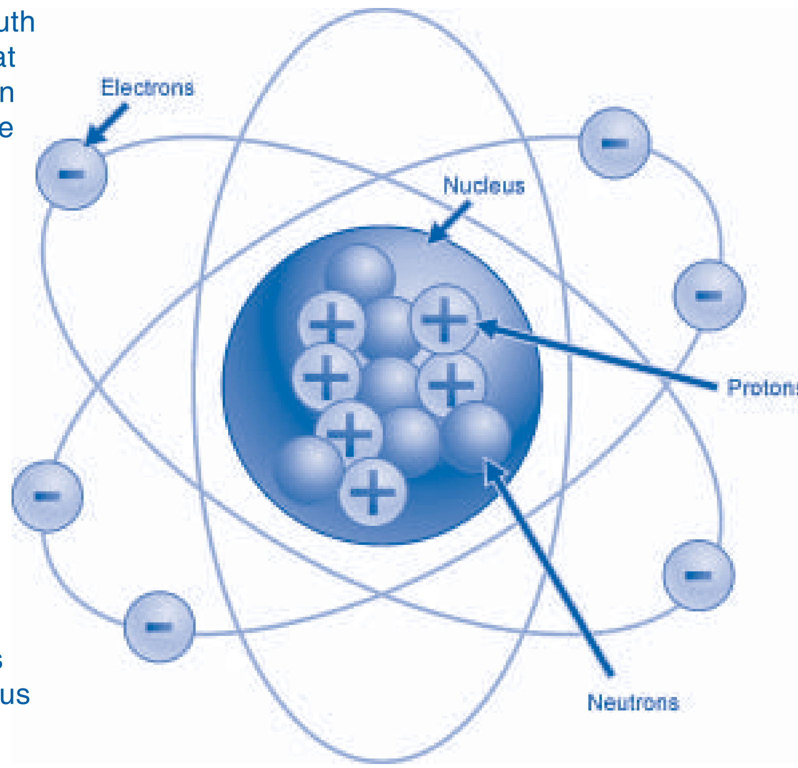
1. When coal is burned, sulfur in the coal combines with oxygen in the air to form sulfur dioxide. Sulfur dioxide is thought to be the principal cause of acid rain. As its name implies, acid rain is precipitation that has an unusually high acidity. The acid in this rain (or snow, fog, hail or dew) causes buildings and roads to erode.

2. Burning coal also releases carbon dioxide into the air. Increased carbon dioxide is believed to keep heat trapped within the Earth's atmosphere. This causes the climate to get continually warmer, a condition known as global warning.

Chapter 5

Nuclear Energy

Nuclear energy plays a major role in South Carolina's energy picture and holds great promise for our energy future. It offers an alternative to fossil fuels, but at the same time carries with it the need for responsible use.



What is nuclear energy?

Nuclear energy is energy released by a nuclear reaction. The process of releasing energy from atoms is difficult to achieve. To understand it, you need to know that *matter* —which is everything that occupies space — is made up of atoms. In the center of every atom is a *nucleus*. Inside the nucleus are particles known as neutrons and protons. Traveling around the nucleus are electrons.

In the diagram of a carbon atom shown here, there are an equal number (6) of protons and neutrons in the nucleus. Six electrons circle the carbon nucleus.

Scientists have learned that when some atoms are bombarded by neutrons they can be made to split, releasing great quantities of heat energy. The process of splitting atoms to release energy is known as *fission*.

When an atom splits, neutrons from its nucleus are shot out at high speeds. They, in turn, cause other atoms to split. A *chain reaction* is thus set in motion.

The first controlled nuclear chain reaction took place at the University of Chicago on December 2, 1942 under the direction of Enrico Fermi. This event ushered in the Atomic Age.

How Nuclear Energy Is Produced

The vast power of nuclear energy can be made to work for us. For example, all nuclear plants convert the nuclear energy in uranium (a very dense metal used as an abundant source of concentrated energy) to electrical energy we can use. When the heat energy produced by fission is transferred to water, it creates steam. The steam is then used to power a generator to make electricity.

How A Nuclear Plant Works

In a nuclear power plant, fission occurs in the *nuclear reactor*. The heat energy produced by fission is captured to use in making steam to run the plant's generators.

In the diagram below, you can see how a nuclear reactor works. Uranium is the fuel used in nuclear power plants. Uranium pellets are stacked in long, metal fuel rods, which are bundled together to form fuel assemblies. These assemblies are then placed inside the reactor.

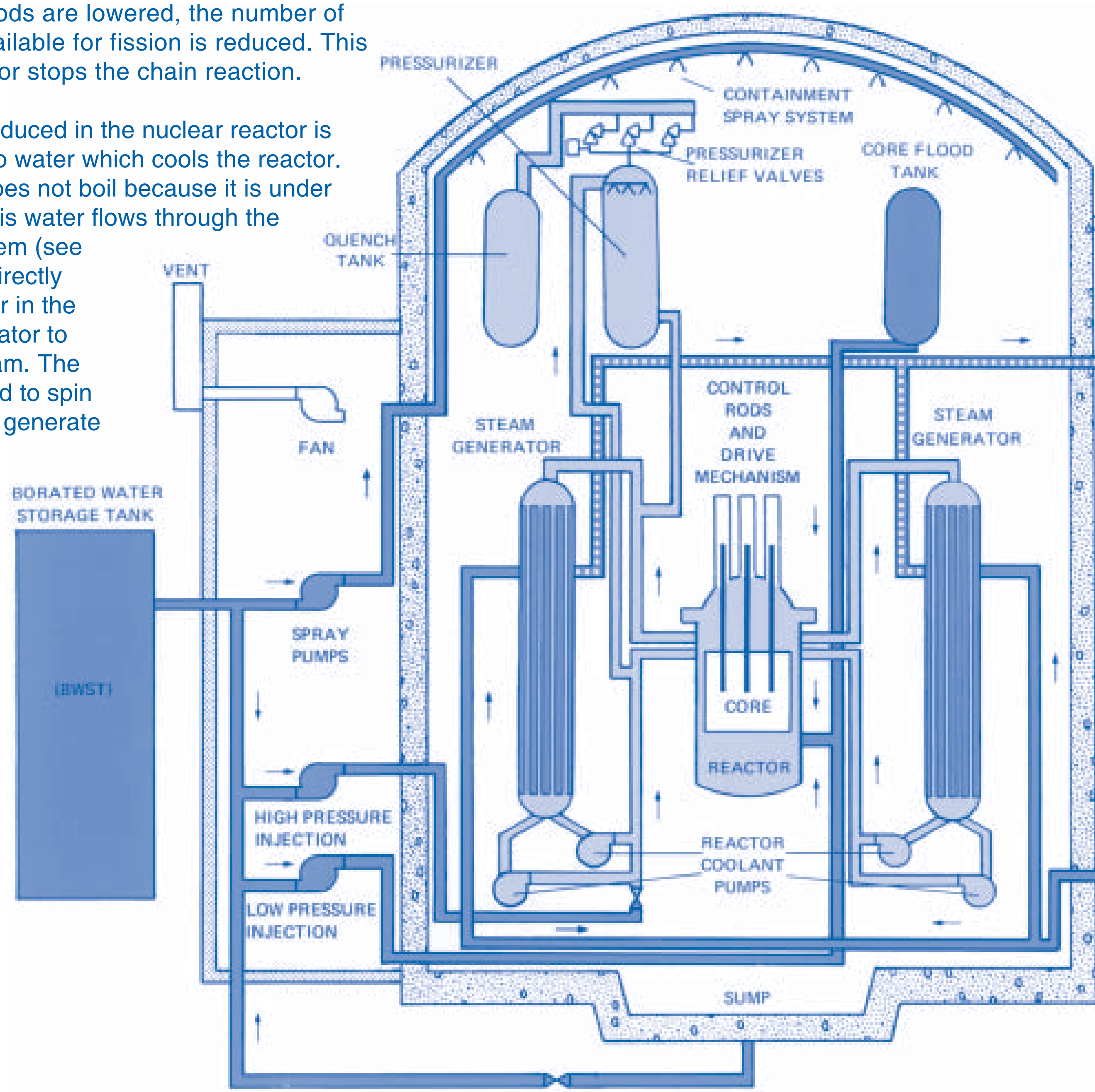
To regulate the fission process, control rods (steel rods containing boron) are used. They act as "neutron sponges." By raising or lowering the control rods into the reactor, the chain reaction is increased or decreased. For example, when the control rods are lowered, the number of neutrons available for fission is reduced. This slows down or stops the chain reaction.

The heat produced in the nuclear reactor is transferred to water which cools the reactor. The water does not boil because it is under pressure. This water flows through the primary system (see diagram) indirectly heating water in the steam generator to produce steam. The steam is used to spin turbines that generate electricity.

Water in a closed system is used to condense the steam. The steam is then returned to the generator to be reused.

Using Nuclear Energy Responsibly

In a world with limited fossil fuels, many people feel nuclear energy has great prospects. It is considered "clean energy" by some. Nuclear energy does not pollute the atmosphere because the fuel is not burned.

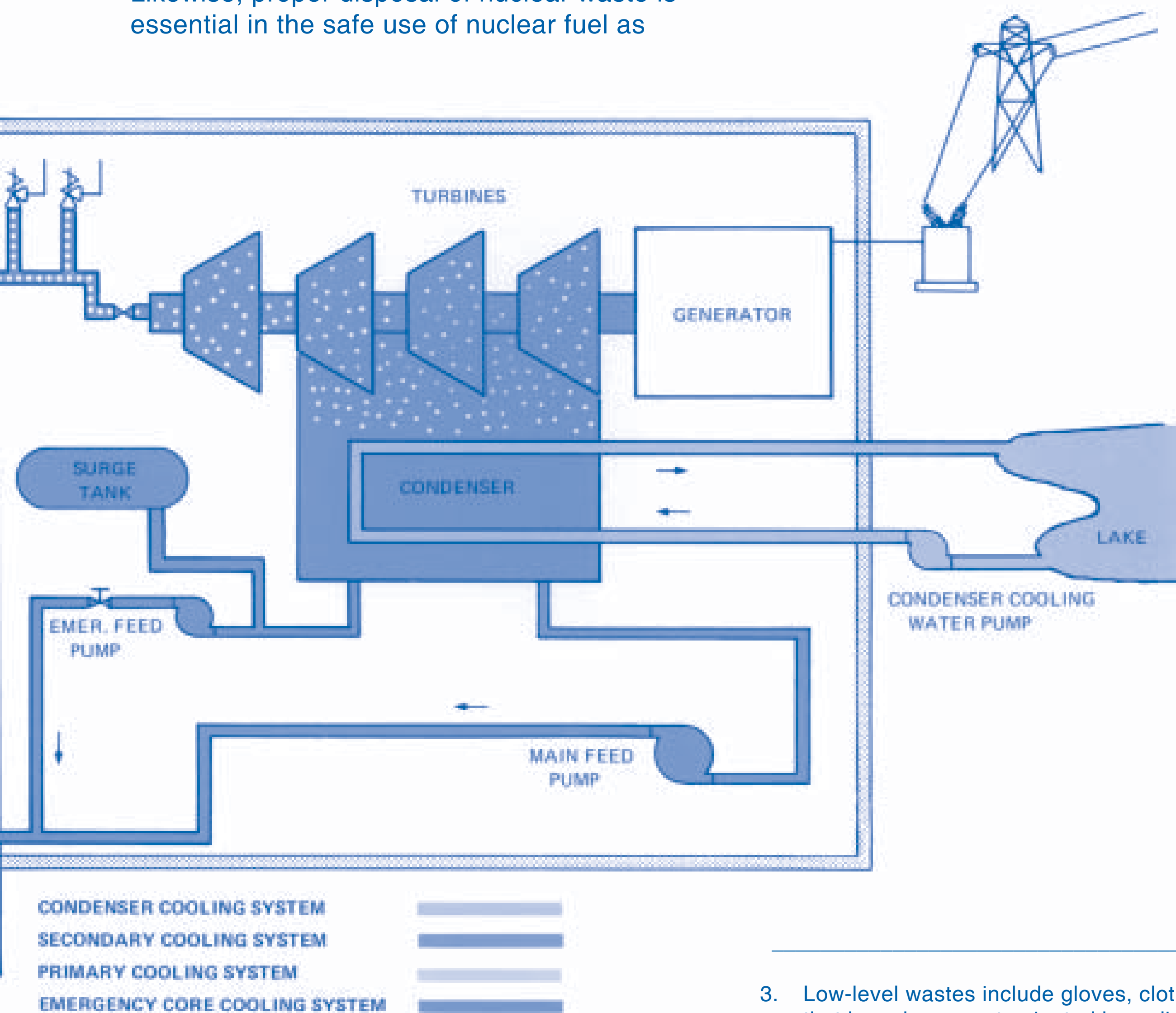


Two main concerns do, however, persist with nuclear energy — radiation and waste disposal. Every time fission occurs, invisible particles are released. These particles, or *radiation*, can be harmful. To prevent radiation from escaping the reactor in which it is isolated, many safeguards have been put into place.

U.S. nuclear power plants are tightly regulated to make sure radiation leakage does not occur. In fact, no nuclear facility can be built or operated without a license from the U.S. Nuclear Regulatory Commission (NRC). Power plants are carefully monitored by NRC inspectors, as well as power plant employees.

Likewise, proper disposal of nuclear waste is essential in the safe use of nuclear fuel as energy. This is especially important in South Carolina since Barnwell County is one of three sites in the United States where low-level nuclear wastes[3] are stored. Some of the precautions taken in handling nuclear wastes include:

- Burying the waste containers in waterproof trenches;
- Regularly checking nearby water wells to ensure that no radiation has escaped; and
- Closely monitoring the area to make sure the waste containers remain undisturbed.



3. Low-level wastes include gloves, clothing and tools that have been contaminated by radiation.

Nuclear Energy in South Carolina

Since the early 1970s, South Carolina has been a leader among states with regard to the use of nuclear power. Only Illinois and Pennsylvania produce more nuclear energy than South Carolina.

In South Carolina we have been able to reduce our use of fossil fuels because of our extensive use of nuclear energy. Nearly one-third (32.5 percent) of the state's energy needs are currently being met by nuclear energy. Nearly 57 percent of the electricity we produce comes from nuclear power.

When the Robinson Plant began generation in 1970, South Carolina became the first state in the South to use nuclear energy for electrical generation. Today there are seven nuclear plants operating in the state. As shown on the map on page 29 in Chapter 6, these include the three Oconee plants, H.B. Robinson in Darlington County, V.C. Summer in Fairfield County and the two Catawba plants in York County.

South Carolina's nuclear facilities have proven to be cost-effective investments. The Oconee facility paid for itself through energy savings in just eight years. In its first 10 years, it became the nation's leading producer of nuclear-generated electricity.

Radioactive Waste in S.C.

Because of South Carolina's investment in nuclear energy, state leaders in the 1960s and 1970s realized that the state would need a regional facility for the safe disposal of radioactive waste.

Radioactive waste comes in many forms. Familiar objects that we encounter on a daily basis can be considered radioactive waste if they become radioactively contaminated. These include uniforms, gloves, construction materials, and tools. Some radioactive waste is less familiar. Filter material used for capturing radioactive elements in the cooling water of nuclear power plants is a common form of radioactive waste. The processed residue from the manufacture of nuclear materials and nuclear weapons is also radioactive waste. Unless they are solidified or absorbed, these take the form of a liquid or sludge.

In the United States, radioactive materials are divided into two groups for purposes of permanent disposal. One group consists of wastes that can be disposed of in the upper 100 feet of the earth's surface in a disposal facility like the one in Barnwell County, South Carolina. This is called "near-surface" disposal. The other group consists of wastes that require a higher degree of isolation in a "deep geologic repository."

Deep Geologic Disposal in the U.S.

The only deep geologic repository currently operating is the federal Waste Isolation Pilot Project (WIPP) located near Carlsbad, New Mexico. The WIPP site accepts long-lived radioactive waste, known as "transuranic waste," from the Savannah River Site (SRS) in South Carolina and other U.S. Department of Energy (U.S. DOE) facilities across the nation.

Another deep geologic repository under development, the Yucca Mountain Site (YMS) in southeast Nevada, will accept spent nuclear fuel from commercial power plants. YMS also will accept high-level radioactive waste that is now stored at U.S. DOE facilities. Included in this will be plutonium wastes and other high-level waste from SRS and other federal sites. Until the YMS begins accepting waste, most spent fuel from nuclear power plants will continue to be stored at the 110 nuclear reactor facilities across the nation in water-filled fuel pools.

The Barnwell Near-Surface Disposal Facility

The U.S. government requires that near-surface radioactive waste disposal facilities be owned by the federal government or by state governments. This is because these facilities will require monitoring, custodial care, and restricted access long into the future. The near-surface disposal facility in Barnwell County is owned by the State

Budget and Control Board and is operated under a lease agreement by a private company. There are currently only two other such disposal facilities for commercially generated radioactive waste in operation in the United States. One is located in eastern Washington State and the other is west of Salt Lake City, Utah.

The facility in Barnwell County was opened in 1971 and has disposed of more than 27 million cubic feet of waste over an area of 100 acres. Waste is placed in large, specially-built trenches. Each trench has a gently sloped floor to prevent accumulation of water during the period the trench is open. A layer of gravel separates the waste packages from any ground water that may intrude during waste emplacement operations. When filled, each trench is capped with a sandy clay material in order to channel surface water away from the trench area. When the site is closed, a permanent multi-layer cap consisting of both natural and synthetic materials will be placed over the entire site as further protection against the intrusion of surface water into the trenches.

As with the other similar facilities, there are strict regulatory limits on the form of the wastes that can be accepted. Wastes cannot include free-standing or unabsorbed liquids. They cannot include chemically hazardous materials. Waste packages must be generally free of air pockets that could cause the trench caps to sink.

Federal and state regulations require an environmental monitoring program to detect any radioactivity outside the trenches. The monitoring program must continue for at least 100 years after the site is closed.

Future of the Barnwell Site

In late 1999, a Governor's task force recommended that a portion of the remaining 3 million cubic feet of disposal capacity at the Barnwell disposal facility be saved for use by nuclear power plants and other industries located within the state. These seven nuclear plants will require a large amount of disposal space in future decades. The task force was concerned that if South Carolina did not take action, the Barnwell site would be filled with waste from other states long before S.C. industries needed it.

Following a recommendation by the task force, the S.C. General Assembly in 2000 joined a three-state alliance with Connecticut and New Jersey called the Atlantic Interstate Low-Level Radioactive Waste Compact. Because the Atlantic Compact had been authorized by the U.S. Congress to limit access to its regional disposal facility to the member states only, this provided the legal authority the state needed to keep out waste from other regions.

The 2000 law also phases out acceptance of radioactive waste from across the nation. By 2009, the Barnwell site may not accept any waste from outside the three-state region.

Conclusion

South Carolina has long embraced the use of nuclear energy. Because the state produces no fossil fuels, nuclear energy allows it to be less dependent on these resources. Clearly, nuclear energy will continue to be important to South Carolina's future.


SOUTH CAROLINA
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Chapter 6

Electricity

Electricity is so much a part of everyone's lives that it is hard to imagine being without it. Yet it has only been since 1882 that electricity has become a reality to us. Before electricity, we had to use kerosene lamps to see at night. Food was cooled by ice transported from cold climates. Rooms were warmed by wood-burning stoves.

Thanks to Thomas Edison and other scientists, everyone can now use electricity to do these things. Today, electricity is so commonplace, most people rarely stop to think about it.

What is electricity?

Electricity is electrons in motion. To understand what is meant by this, look again at the diagram of the carbon atom shown on page 19. The electrons surrounding the nucleus of an atom are only loosely held in place. This makes it easy for them to fall out of orbit.

When this happens, an electron becomes a *free electron*. Practically everything around us contains free electrons. Typically, free electrons move about randomly. However when force or *voltage* is applied, the free electrons move in an orderly fashion. This movement of free electrons under the influence of force is known as *electrical current*.

Electrical current will flow as long as voltage is applied. This is how batteries and power plant generators work. It's also what happens to lightning during a thunderstorm.

The History of Electricity

People have known about electricity since before the time of the Ancient Greeks. But scientists didn't set out to make electricity work for them until the turn of the 19th century.

One of the first uses was in arc lighting. Invented by Sir Humphry Davy in 1808, arc lights were used outdoors in place of gas lights. They were, however, too hot and too big to bring indoors. They were also expensive.

It took the great inventor Thomas Edison to figure out how to bring lighting indoors. In 1878, the 31-year-old Edison announced to the world that he was going to tackle the problem of producing light using electricity. Nearly everyone was convinced that the man who had already invented wax paper, the mimeograph machine, the stock ticker and the phonograph could accomplish this feat of wizardry.

One year and thousands of experiments later, Edison achieved his goal. Using scorched cotton sewing thread and electricity, Edison produced 40 hours of continuous light. The light bulb was born.

Other ideas of Edison's actually brought electricity into our homes. Over a three year period, he created electrical switches, sockets, fuses, meters, and transmission and distribution lines. He also developed an electrical generating system. Generators use mechanical energy to produce electricity.

On September 4, 1882, Edison and his colleagues generated electrical current from New York City's Pearl Street Station into 85 homes and businesses. Edison noted at the time, "I have accomplished all that I promised."

After Edison's breakthrough, the use of electricity grew quickly in America. Today electricity is so central to everyday life that most people take it for granted.

How Electricity Is Produced Today

Steam Power

Today, most of the electricity used is produced by power plants. The most common method uses steam. Coal, gas, oil or nuclear fuel is used to produce heat to make steam.

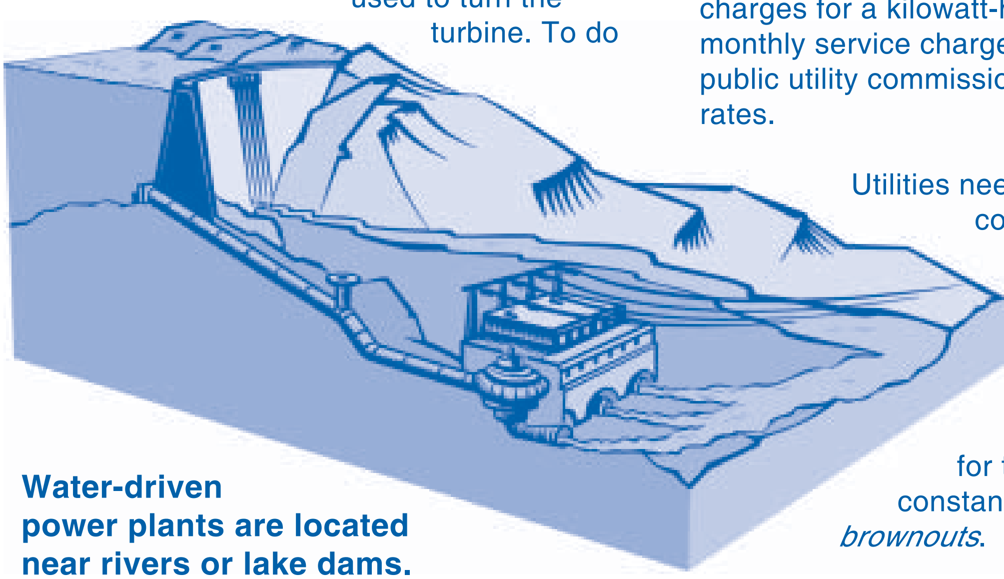
To view how this process works, turn to the diagram of a nuclear reactor on pages 20 and 21. Steam is piped to the turbine. The turbine's shaft is connected to a huge magnet in the generator. As steam turns the turbine, the magnet spins inside a coil of wire. This spinning action creates a force which causes the electrons on the metal wires to flow. Thus, electrical current is produced.

From here, the electricity flows to the power plant transformer where it is "stepped up." After leaving the power plant, the electricity flows to substations of local utility companies. Here, the voltage is "stepped down" to a usable level. Electricity then flows through distribution lines from the substations to customers in the residential, industrial and commercial sectors.

Water Power

Water power also can be used to generate electricity. Instead of steam, moving water is used to turn the turbine. To do this, water in great force is needed. This is why water-driven plants are located near rivers or lake dams. Think of Niagara Falls. It is the ideal locale for a *hydroelectric plant*.

Hydroelectric plants have been in existence since before 1900. In 1900, 57 percent of the electricity produced in this country came from water power. Today, hydroelectric power accounts for just three percent of the electricity generated in South Carolina. This is mostly due to the fact that lakes and rivers are currently being used to their full capacity.



Water-driven power plants are located near rivers or lake dams.

Utilities and Their Customers

How Electricity Is Sold

In most cases, South Carolina's electricity is generated by power plants owned by the utilities. The utilities then sell the electricity to their customers. The electricity flows to a home or building through a distribution line and enters the facility at the meter point.

Meters measure the amount of electricity used in kilowatt-hours. One kilowatt-hour is about the amount of energy needed to run an iron for one hour.

The cost of the electricity is determined by multiplying the number of kilowatt-hours used each month by the cost the utility company charges for a kilowatt-hour of electricity, plus a monthly service charge. Federal, state and local public utility commissions determine these rates.

Utilities need to anticipate consumers' demand for electricity. During hot summer days, everyone wants the air conditioner on high. Were the electric companies not prepared for this, there would be constant power shortages or *brownouts*.

Anticipating demand is important because electricity cannot be stored. To meet peak needs, utilities must generate all of the electricity they can and shift demand for electricity to off-peak times (late at night) or incorporate energy saving measures. Sometimes they even have to purchase electricity from other utilities.

Load Management

To be prepared, modern utilities practice *load management*. Load management is the balancing of electricity supply with consumer demand.

The goal of load management is to even out the peaks and valleys of electricity use. Peak use usually occurs on hot summer afternoons in South Carolina. They also include winter mornings and evenings when lights and furnaces are on. Off-peak times occur on weekends and at night. This is when most offices, factories and schools are closed.

Several load management techniques are used. Direct control allows the utilities to switch the flow of electricity on or off. During peak load times, customers allow the utility to temporarily shut down electricity to a customer's central air conditioning unit or electric water heater. When the peak demand is over, power is returned. Customers who allow the utilities to add switches to their meters receive monthly credits on their utility bills.

Time of use pricing rewards customers who use electricity during off-peak hours. Conversely, customers who use electricity during peak hours may be charged higher rates. This also is a voluntary program, used by industries who can shift load.

Some utilities also make use of pumped-storage power plants to help with load management. These facilities produce electricity during peak times. The diagram on the next page shows how a pumped-storage plant works.

Pumped storage plants actually use more energy than they generate. Even so, they are cost-effective. This is because other ways of meeting peak electricity demands are even more expensive.

Electricity In South Carolina

South Carolina's use of electricity continues to increase. During the last 20 years, the amount of electricity produced and used in the state has more than tripled.

As the state's economy has grown, so has its need for electricity. South Carolina power plants generate about 90 billion kilowatt hours of electricity each year. About 57 percent of this electricity comes from nuclear power plants. Coal-fired plants produce almost all of the remaining electricity. Just under four percent of our electricity comes from plants powered by petroleum, natural gas or water.

South Carolina's electricity is provided by private investor-owned utilities, city-owned utilities, rural electric cooperatives and a state-owned utility.

The Investor-owned Utilities

Four investor-owned utilities serve South Carolina: S.C. Electric and Gas (SCE&G), Duke Power, Progress Energy and Lockhart Power Company. These utilities each have an assigned service territory and a legal obligation to serve all the consumers in their territories, and are regulated by the S.C. Public Service Commission and federal regulations. Each investor-owned utility is owned by thousands of investors who have stock in the company.

SCE&G has its headquarters in Columbia and is an important supplier of electricity in the state. It maintains 3,440 miles of transmission lines and 15,713 miles of distribution lines which serve more than 531,000 customers in the Midlands and Low Country. SCE&G generates and sells about 17 billion kilowatt hours of electricity each year.

Duke Power, headquartered in Charlotte, N.C., serves 500,000 customers in South Carolina's Upstate region. This large utility, which sells more than 82,000 gigawatt hours of electricity annually in South Carolina, maintains about 12,500 miles of transmission lines and 52,000 miles of distribution lines in the state.

Progress Energy, like Duke Power, also is based in North Carolina. Progress Energy's headquarters is in Raleigh, N.C. and serves about 165,000 customers in the Pee Dee region of South Carolina. Progress Energy sells 7 billion kilowatt hours of electricity each year in South Carolina, and that electricity is sent to S.C. customers over its 1,900 miles of transmission lines and 8,123 miles of distribution lines.

Lockhart Power Company provides electric service to about 14,000 customers over its 90-mile transmission network. Lockhart maintains about 750 miles of distribution lines, sending 85 million kilowatt hours of electricity annually to its customers, and has the distinction of offering among the lowest electrical rates in South Carolina.

Santee Cooper: South Carolina's Public Utility

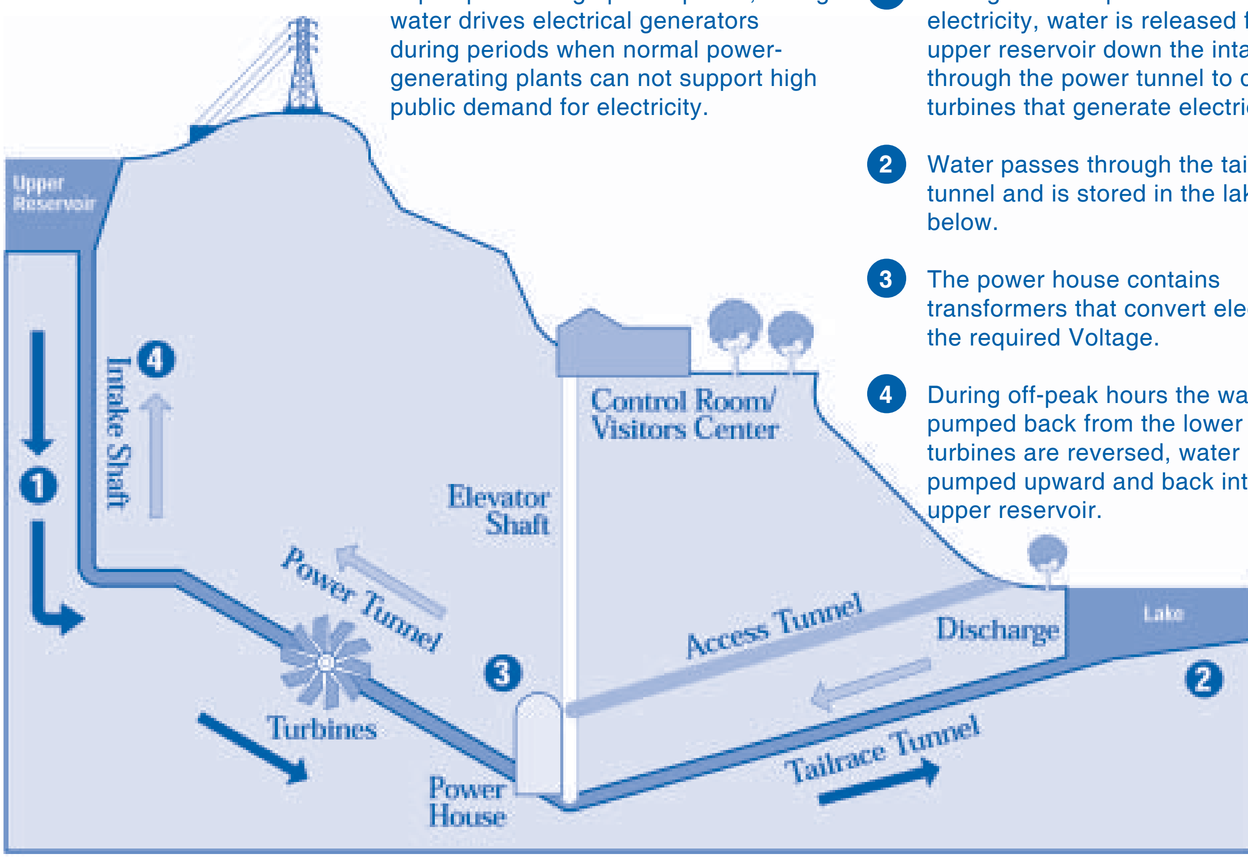
Santee Cooper is the state's public utility. It was created in the 1930s to bring electricity to rural areas. When it started, less than three percent of South Carolina's farms had electricity. A decade later, Santee Cooper supplied electricity to 91 percent of the farms in the state, mostly by providing wholesale power to South Carolina's electric cooperatives.

Santee Cooper, headquartered in Moncks Corner, now generates about 24 million megawatt hours of electricity each year. That electricity is sold to 135,000 retail customers and all of the state's 20 electric cooperatives. That electricity travels more than 4,424 miles of transmission lines and 2,222 miles of distribution lines.

Pumped-storage Power Plant: Recycling Water to Make Electricity

In pumped-storage power plants, falling water drives electrical generators during periods when normal power-generating plants can not support high public demand for electricity.

1. During hours of peak demand for electricity, water is released from the upper reservoir down the intake shaft through the power tunnel to drive turbines that generate electricity.
2. Water passes through the tailrace tunnel and is stored in the lake below.
3. The power house contains transformers that convert electricity to the required Voltage.
4. During off-peak hours the water is pumped back from the lower lake; turbines are reversed, water is pumped upward and back into the upper reservoir.



The Electric Cooperatives

About one-third of South Carolina's citizens get power from electric cooperatives (co-ops). Some co-ops are owned by the producers of the products or services they sell, but electric co-ops are owned by the users of the product (electricity). In other words, the consumers also are member-owners of the co-ops.

Electric cooperatives service more than 70 percent of the land area in South Carolina and serve consumers in every county in the state. Co-ops are located mostly in rural areas, small towns and suburbs of large towns. In order to reach rural locations, the cooperatives have to use a lot of power lines. In fact, the co-ops use and maintain more than 82,000 miles of distribution lines, more than all other S.C. utilities combined, in order to bring power to their more than 610,000 consumers.

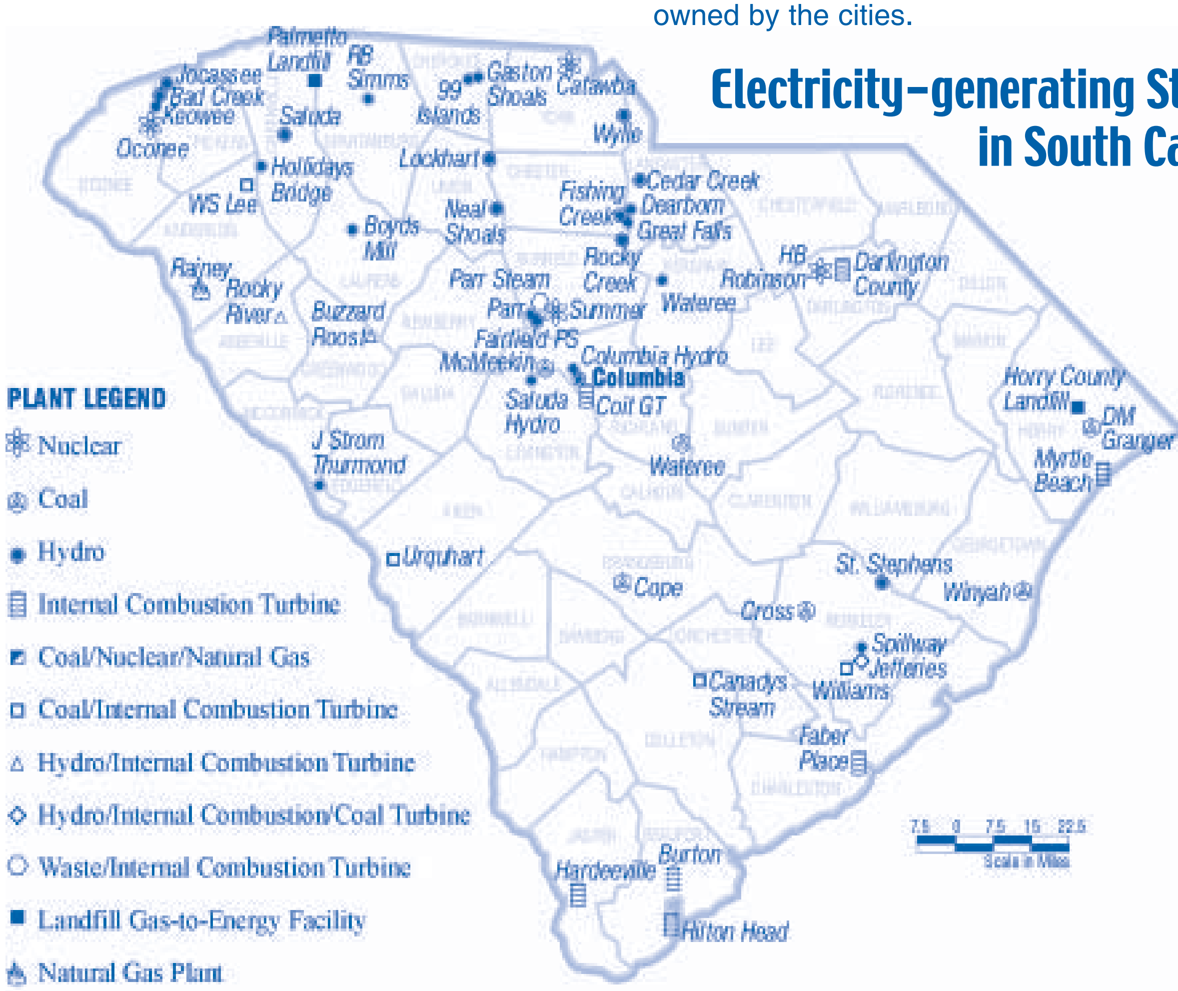
Most of the electricity sold by electric cooperatives is purchased wholesale from Santee Cooper. The co-ops operate on a not-for-profit basis, so all revenues above the cost of doing business are returned to the consumers in the form of credits.

Seventeen of South Carolina's 20 electric cooperatives are members of Touchstone Energy® – a national alliance of local, consumer-owned electric utilities committed to providing superior service and affordable rates to all customers, large and small.

South Carolina's Electric Cities

South Carolina also has 22 municipal electric utilities. These 22 "electric cities" provide electricity as a public service. This electricity is often referred to as "public power." Local governments purchase electricity from investor-owned utilities and Santee Cooper at wholesale prices and then distribute the power to customers at retail rates. Distribution systems are owned by the cities.

Electricity-generating Stations in South Carolina



Overall, South Carolina's electric cities sell more than 14 billion kilowatt hours of electricity to 288,000 customers each year. That electricity runs through 20,085 miles of distribution lines in order to reach its customers.

How We Use Electricity

The industrial sector uses a great deal of the electricity produced in South Carolina. About 41.5 percent of the electricity generated goes to operate factories and mills. Many of South Carolina's industrial users of electricity are scattered across the state, but the heaviest concentration of industrial facilities is in the Piedmont counties of Greenville, Spartanburg and Anderson.

One-third of the electricity produced in the state is used in private homes. Everything from the basic (refrigerators and lights) to the frivolous (bath towel warmers and game stations) runs on electricity.

More than 13 percent of South Carolina's electric energy goes to commercial customers. Again, the biggest users are in Greenville and Spartanburg counties. Charleston County is one of the biggest users of both commercial and residential electricity.

Conclusion

Electricity is an important part of South Carolina's energy past, present and future. Its utilities provide electricity to even the most rural areas. Modern technologies, including the use of nuclear fuel and pumped-storage, produce energy to meet the needs of all sectors of the state's economy.

Chapter 7

Renewable Resources: Sun, Wind, Wood and Other Biofuels

Chapter 4 highlighted the use of fossil fuels. Fossil fuels are termed nonrenewable because they are in limited supply. This chapter will focus on resources that are readily available and *renewable*.

Renewable Energy

Renewable energy includes all of these forms of energy found on the planet — the sun, wind, wood and other biofuels. They make it possible to put the environment to work in positive ways. The use of renewable resources demonstrates energy technology at its creative best.

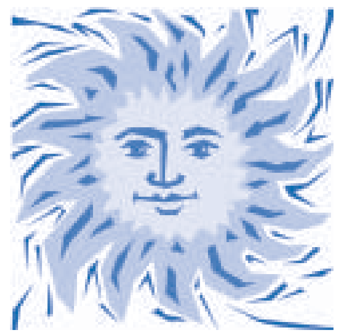
The Sun

The sun is the most powerful energy resource. It heats the planet and nourishes plants used for food. Without the sun, nothing could exist.

The energy from the sun is there for the taking. It is not only free, it never runs out. If all the sun's energy that falls on one square meter of the Earth's surface for one hour could be harnessed, a whole city could be lit for one year. Also, the energy from the sun poses no environmental hazards.

The Challenge of Tapping the Sun's Energy

With these many advantages, why is solar energy not being used to meet all of our energy needs? The answer is that tapping the sun's energy is not a straightforward process.



For maximum use of the sun, it must be constantly available. Yet, even under ideal weather conditions, the sun does not shine 24 hours a day, 365 days a year. To be useful, sunlight must be collected, moved to where it is needed and stored. This is no easy challenge.

People have been using the sun's energy for thousands of years for space and water heating purposes. With the beginning of the space age, scientists were able to develop a system that converts sunlight into electricity. This is called a photovoltaic system. Utilizing the sun's energy is categorized into four main systems: (1) active systems; (2) passive systems; (3) photovoltaic systems; and (4) hybrid systems.

The last, a hybrid system, is some combination of the other systems. In all of the systems, they must face the sun in order to work. For the northern hemisphere of the earth, where we live, the sun moves across the sky during the day from the southeast to the southwest. This creates the problem of where to face the system to get the maximum amount of energy from the sun. The answer is to position the system so that it faces due south, or only slightly east or west of south.

Active Solar Systems

Active solar systems use mechanical equipment such as pumps and fans to move energy around. There are two types of active systems; one is for space heating and the other is for water heating. A house using active space heating will have to face south, with most of its windows on the south wall. This allows winter sunlight to enter the house, thereby heating the air inside. This heated air is then circulated throughout the house by fans.

When sunlight passes through glass into an enclosed space, the wavelength of the light changes. This new wavelength can not pass back through the glass, thereby entrapping it in the house. This is known as the *greenhouse effect*. Think of it just like getting into the car on a cold winter day and finding the inside of the car warm.

More equipment needs to be added to the system if night time heating is necessary. The air is heated in collectors and circulated through a rock bed storage compartment. This is an insulated box which contains small rocks. These rocks are heated during the day, and at night, the air inside the home is circulated through the rock bed. As it passes through the rocks, it extracts the stored heat, and heated air is circulated back through the house.

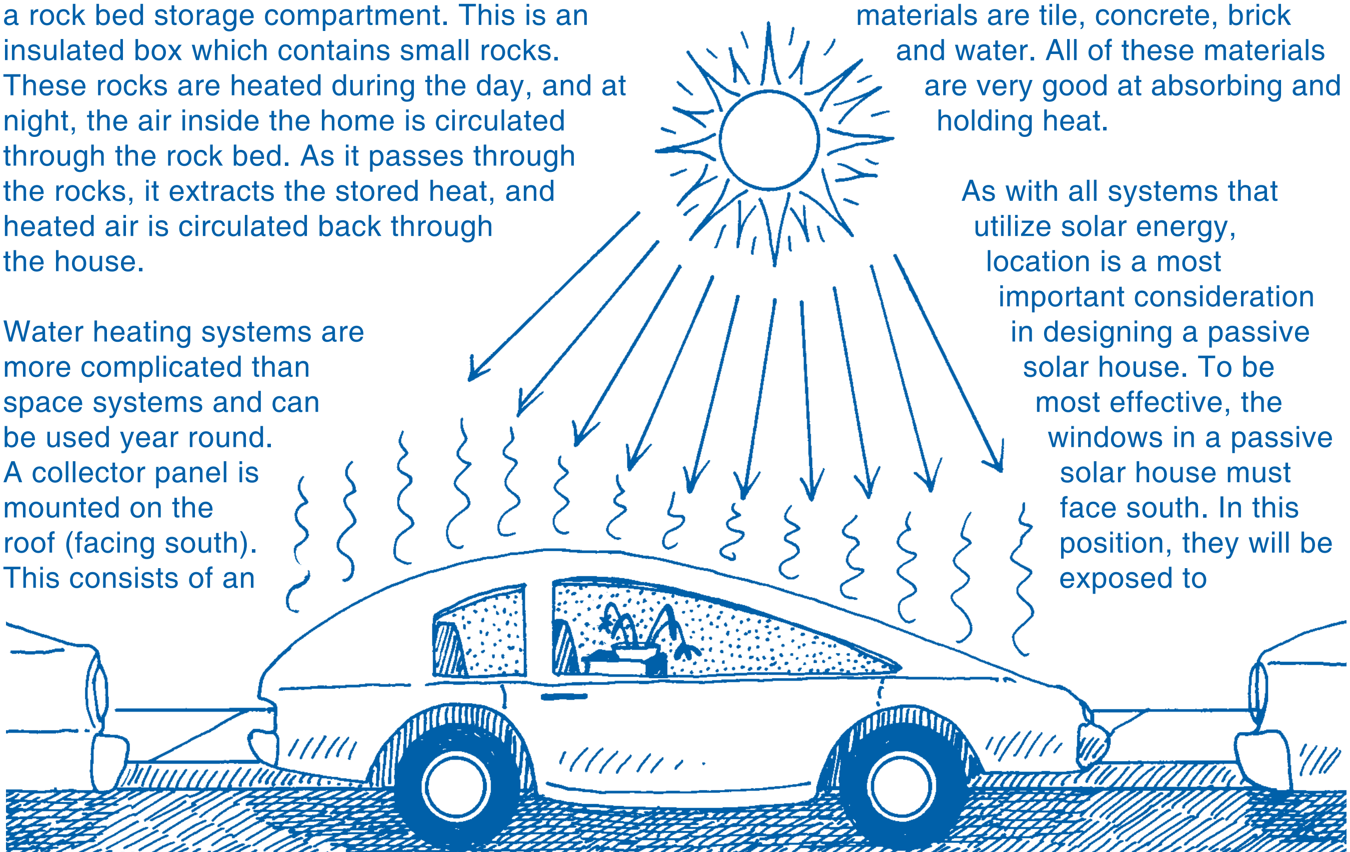
Water heating systems are more complicated than space systems and can be used year round. A collector panel is mounted on the roof (facing south). This consists of an insulated box with a clear glass or plastic cover. Inside this panel are many copper pipes and fins. These pipes are painted black to absorb and conduct the sun's heat to the water that is pumped through them.

This collector panel is attached to the water heater tank which is located inside the house. The water is circulated between the collector and the water tank by electric pumps. Cold water is pumped from the water tank to the collector and hot water is pumped back from the collector to the water tank. *Thermosensors*, which recognize changes in temperature, tell the pump when to turn on and off.

Passive Solar Systems

Passive solar systems do not use any mechanical equipment to move energy. In these systems, the actual building components become part of the system. These components, or thermal storage materials, are used to store heat during the day for use at night. Among the most commonly used thermal storage materials are tile, concrete, brick and water. All of these materials are very good at absorbing and holding heat.

As with all systems that utilize solar energy, location is a most important consideration in designing a passive solar house. To be most effective, the windows in a passive solar house must face south. In this position, they will be exposed to



The Greenhouse Effect

maximum sunlight. In addition, insulation should be placed around the glass to reduce heat loss. Windows, doors and walls need to be free of leaks so that trapped heat stays trapped.

Outside landscaping is another important part of passive solar systems. For example, evergreen trees that won't lose their leaves in winter can be planted on the north side of a home to provide winter wind protection. Trees that lose their leaves in winter can likewise be planted on the south side of a home to give it access to winter sunlight and to protect it from hot, summer sunshine.

Photovoltaic Solar Systems

Photovoltaic systems convert radiant energy from the sun into electricity. While photovoltaic technology has been around for 150 years, its actual commercial development did not occur until 1954. It was first used in 1958 to provide electric power for U.S. spacecraft and satellites.

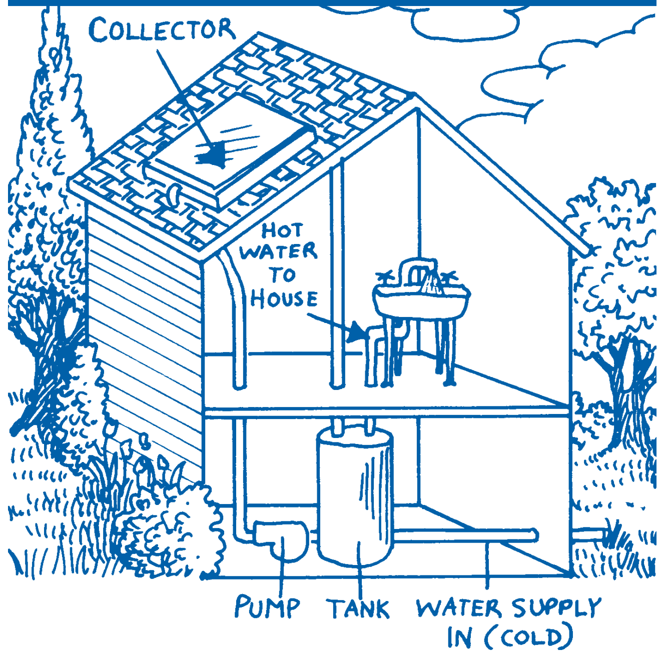
The cost of producing electricity through photovoltaic technology has dropped significantly in the past few years. Prices have gone from more than $50 per kilowatt to less than $0.30 per kilowatt. Photovoltaic systems, once seen as too expensive, are being used more frequently.

Photovoltaic systems are often used in remote areas where it is too expensive for power companies to bring in electric power lines. They also are being used to light road signs and power radio transmitters. Researchers developing electric cars also are making use of photovoltaic technology. Scientists at York Technical College in South Carolina, for example, are among those working hard to improve this technology.

Wood and Other Biofuels

Wood is one of the most plentiful forms of biomass (chemical potential energy) on the planet. More than 30 percent of the earth is covered by trees. Wood itself accounts for more than 80 percent of the biomass fuels used in the United States.

An Active Solar System



Wood was once the primary source of energy. From the time of the caveman it has been used as fuel. People learned that burning wood could be used to keep one another warm, to ward off animals, to light up the darkness and to cook food. Wood became the basis for early civilization.

Until the beginning of the previous century, wood's importance reigned supreme. As noted in Chapter 1, in the 1850s, 90 percent of all energy used in the United States was from wood. The Industrial Revolution was fueled by wood's energy. The commercial and residential sectors used wood for space heating, water heating and cooking. Fireplaces and wood stoves became familiar furnishings in most every home. Wood-powered steam locomotives and ships transported settlers across the country. Almost all aspects of everyday life was dependent on wood.

The use of fossil fuels as an energy source abruptly put an end to wood's popularity. The ease with which fossil fuels could be used made wood seem old fashioned. In South Carolina, dependence on wood lasted much longer than in many other parts of the country. Up until the 1960s, wood was one of South Carolina's primary fuels.

For about a decade following the Energy Crisis of 1973, it seemed that wood would make a comeback. However, once oil prices dropped, most Americans stopped using wood for everything except some space heating. In 1991, the U.S. Energy Information Administration reported that fuel wood use for water heating and cooking "has just about disappeared." This remains true today, as wood provides only three percent of the state's total energy needs.

The one economic sector that still makes use of wood energy is industry. The paper and lumber producing industries together account for almost all of the wood energy used today. Both of these industries use wood waste for steam, heat and to produce electricity.

Wood also can be used to make ethanol vehicle fuel, but the current process is quite expensive.

Biofuels have their origin in plants. During photosynthesis, the sun's energy is turned into biomass. Biomass can be used as it is, turned into a gas or processed into fuels such as methane, ethanol or methanol.

Energy from biomass is receiving much attention today. Though it accounts for only four percent of the energy used in the United States, it is an area with much potential.

Other Biofuels

Two other types of biomass have energy potential. These are *alcohol fuels* and *waste products*.

Alcohol fuels can be produced from crude oil, natural gas and coal. Through heating, methanol and ethanol are released. Methanol also can be obtained by gasifying wood. Ethanol can be made by *fermenting* corn or grains such as sorghum, barley and oats. Technologically, almost anything that grows can be used to make ethanol. Fermentation involves turning the starch in the corn or grains into sugar.

Methanol can be used as a transportation fuel. In fact, Henry Ford ran his Model T on methanol. Ethanol is frequently added to gasoline as an "extender." It also is blended with gasoline to form gasohol. In the 1970s, gasohol found short-lived fame as a gasoline substitute. Ethanol's future as a true substitute for gasoline is less certain these days. Right now, it is more costly to make than petroleum. However, federal tax benefits have kept development costs in check. If the price of corn (from which it is typically made) goes down and the price of crude oil (from which gasoline is made) goes up, ethanol is likely to become a more attractive alternative.

Waste Products

Organic Wastes

Organic wastes are usually divided into two categories — municipal waste and industrial waste. *Municipal wastes* includes household garbage and waste from office buildings, restaurants and supermarkets. *Industrial wastes* are the biological by-products produced by manufacturing. These include food, food processing remains and packaging material including paper, cardboard and straw.

Steam from Waste Incineration

Using municipal wastes for energy began in the 1980s as a response to the need for more landfills. Since trash is 75 percent burnable, landfill materials can be burned in specially designed incinerators. The produced heat is then converted into steam. Burning refuse not only creates steam energy, it reduces the volume of waste going to the landfill by 90 percent.

Industrial wastes are converted into wood fuel used for heating, electricity and the operation of industry. The pulp and paper companies, as described earlier, are the largest users of industrial waste energy.

In South Carolina, the largest user of municipal solid waste energy is the Foster Wheeler plant in Charleston (right). This plant produces steam and electricity by burning municipal solid waste.

Landfill Methane Gas

There are options for waste other than burning. Spartanburg's BMW automobile manufacturing facility has become the first direct use, non-utility company in South Carolina in more than two decades to recycle landfill methane gas as a source of energy. It is the only such facility now operating in the state.

Waste Management, Inc. (WMI), the largest waste handler and recycler in the world, supplies the methane gas from its Palmetto Landfill to Ameresco Energy Services. Ameresco cleans the methane, processes and compresses it, and delivers it nearly 10 miles to the BMW facility.

BMW has signed a 20-year purchase contract for the gas, and uses it to fuel four plant turbines. The turbines generate electricity and heat water, supplying about 20 percent of the facility's energy needs. This ultimately reduces the amount of fossil fuel burned at the 2.5 million square-foot facility and replaces it with a stable supply of renewable energy.

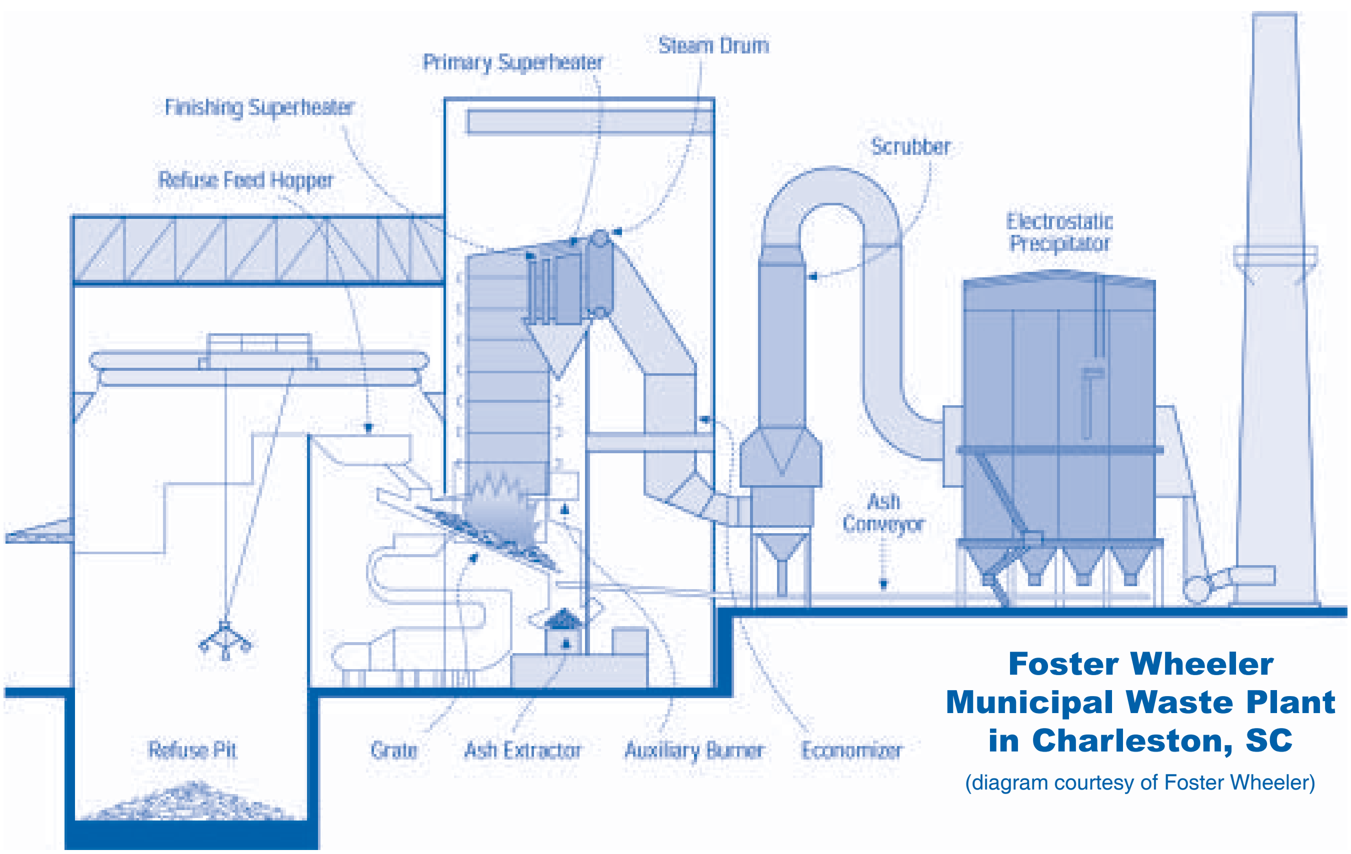
The project has an equivalency environmental benefit of removing 61,000 cars a year from the highways, every year, and an energy equivalency value of saving 80,000 to 100,000 barrels of crude oil each year the project is in operation.

An agreement was signed between the Lee County Landfill and Santee Cooper in 2003. The Lee County site will initially generate five megawatts, and eventually increase to about 12 megawatts. Santee Cooper will work with Black River Electric Cooperative to route electricity to the grid.

Animal and Human Wastes

One final group of waste products that need to be considered as potential energy sources are animal and human wastes. Referred to as agricultural waste and sewage sludge, these types of wastes have only recently been seriously considered for energy. Currently, no data is collected on their energy use, so it can only estimate how widely they are being used.

Animal waste (otherwise known as manure) is obtained from animals raised in confinement. This means that only a limited area needs to be



Foster Wheeler Municipal Waste Plant in Charleston, SC

(diagram courtesy of Foster Wheeler)

searched for collection. The droppings of dairy cattle, beef cattle, hogs and poultry are removed to covered ponds or vats known as *digester vessels*. Here, they are biologically converted into methane gas. The produced methane gas is used for space heating, as a boiler fuel or for generating electricity. Large dairy farms can use agricultural wastes collected on-site to fuel their own operations.

Human wastes also can be used for energy after being processed by public treatment facilities. Energy recovery processes, however, still are largely experimental. *Sludge*, made of water-logged solids formed when sewage is treated, can be burned or turned to methane.

Water treatment facilities are able to use sludge to fuel their operations. At present, however, technology only has been able to recover enough energy from sludge to supply about 34 percent of the energy needed to operate water treatment plants.

Wind

Wind is the reaction of the atmosphere to the earth's heating and cooling cycles. During the day, the sun's heat causes low pressure areas to form. At night, the loss of heat to space results in high pressure areas. When air flows from high pressure areas into low ones, wind is produced.

Using wind for energy is an idea almost as old as the wind itself. The ancient Egyptians used wind energy to sail to other ports-of-call. For hundreds of years, the Dutch and other Europeans built windmills to capture the wind's energy. Windmills captured the kinetic energy in wind and turned it into mechanical energy. The turning blades of the windmill were used to turn stones to grind grains.

In the United States, windmills have been used since pioneer times. Until the beginning of the 20th century, they were common fixtures in the Great Plains. Farmers used windmills to pump water. For many years, they also were used to generate electricity.

Today, wind power is again being used to make electricity. Modern windmills act as both turbines and generators, turning the wind's kinetic energy into electrical energy. At present, this way of making electricity is expensive and is viable only in certain geographical regions. To harness enough wind to make it effective, wind farms with hundreds of wind turbines would have to be built.

These operations not only take up great areas of land, but have other drawbacks, too. First, the wind is an unpredictable power source. It may dwindle to nothing or reach gale force with little warning. Large operations also are noisy and not very energy efficient.

Despite these drawbacks, engineers in Texas, California and Hawaii are succeeding in making wind-generated electricity cost-effective. Windmills in the ocean also are being considered. While wind has much potential as a clean source of electricity, it currently accounts for a small fraction of all electricity generated in the United States. South Carolina has few sustained winds and very little potential for ever using a significant amount of wind energy.

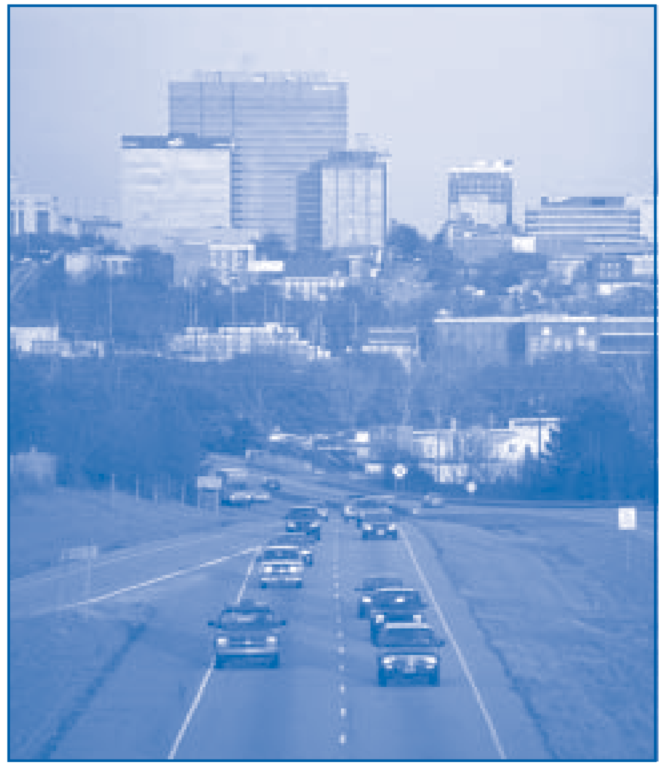
Conclusion

All of the renewable resources covered in this chapter hold great promise in the future. Even though wood and wind energy have been used since the dawn of civilization, they are being regarded in new, more efficient ways today. Scientists are hard at work determining how to make more effective use of all renewable resources.

Chapter 8

Alternative Transportation Fuels

What are alternative fuels?



The term *alternative fuel* is used to describe fuels other than gasoline that can be used to power our cars. In 1992, the U.S. Congress passed a law called the “Energy Policy Act.” This Act made it a law for governments and utilities to use alternative fuels made in the United States to power some of the vehicles in their fleets. The fuels that must be used are natural gas, propane, electricity, ethanol and biodiesel.

Why are alternative fuels important?

The United States uses more oil than any other country in the world and a little less than 50 percent of that oil comes from the U.S. The rest of it is imported mostly from Middle Eastern countries. The United States’ dependence on oil from other countries makes it very vulnerable and jeopardizes national security.

In the 1970s, the Arab nations of the Organization of Petroleum Exporting Countries (OPEC) announced an *embargo* on exporting oil to the United States. This means that they decided to not sell oil to American companies any more. They did this because they were angry that the United States supported Israel in the Arab-Israeli War. As a result, oil prices in the United States skyrocketed because there wasn’t enough for everyone. Gasoline was *rationed,* meaning that people were only allowed to buy it on certain days and often after long waits. This had a severe effect on our economy and President Richard Nixon announced that the United States must attempt to use less oil.

Congress passed many laws in the 1970s to achieve this goal and those laws received support from Presidents Gerald R. Ford and Jimmy Carter. Some of these included new vehicle efficiency standards, and also the 55 mile-an-hour speed limit. This was passed because vehicles operate most efficiently at this speed. All these laws had a positive effect.

Oil prices rose again in 1978 with the Iranian Revolution and in 1992 following the Gulf War. In 1992, President George Bush, father of the President George W. Bush, championed the passage of the Energy Policy Act. This law was intended to drastically reduce our dependence on foreign oil by increasing the use of domestically-produced fuels in government and utility-provider fleets. Beginning in 1996, fleets were required to begin purchasing alternative fuel vehicles (AFVs). The percentage of AFVs was increased each year and by 2001, 75 percent of new vehicles purchased had to be capable of using alternative fuels.

In spite of this law, demand for oil continues to rise. Now Americans are using roughly 19.5 million barrels of oil a day, the most ever in our history, with 54 percent of it coming from foreign countries.

Such widespread use of oil has another effect besides oil dependence. Overuse of fossil fuels has caused significant air pollution throughout the United States. When most people think of air pollution, they think of Los Angeles or Houston. However, Charlotte and Atlanta, our neighbors to the north and south, have some of the highest pollution rates in the country. Even in South Carolina, air quality is threatened by emissions from gasoline-powered cars and trucks. Fortunately, alternative fuels can help ease those problems as they burn more cleanly than gasoline and diesel fuel.

The Alternative Fuels

Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG)

Natural gas is domestically produced and readily available in the United States. Natural gas also is clean burning and produces less pollutants than reformulated gasoline. Natural gas can either be stored on board a vehicle in tanks as compressed natural gas (CNG) or cryogenically cooled to a liquid state – liquefied natural gas (LNG).

Natural gas is a mixture of hydrocarbons — mainly methane (CH_4) — and is produced either from gas wells or in conjunction with crude oil production. Natural gas also is used for heating and cooling homes, cooking, clothes drying and in businesses.

Although one of the cleaner-burning alternative fuels, natural gas is not yet common or used very widely. The vehicles typically cost about $3,500-$5,000 more than a regular gas vehicle and the refueling stations cost anywhere from $400,000 for a "fast-fill" station that fuels each vehicle in just a few minutes to $3,500 for an in-home compressor that fills a vehicle overnight.

Propane (Liquefied Propane Gas, LPG)

Propane or liquefied petroleum gas (LPG) is a popular alternative fuel choice. In fact, propane has been used widely for years in agricultural communities. Like natural gas, propane produces fewer vehicle emissions than reformulated gasoline. Propane is produced as a by-product of natural gas processing and crude oil refining.

Propane is a simple mixture of hydrocarbons, mainly propane/propylene (C3S) and butane/butylene (C4S). Propane also is a popular choice for home heating and outdoor cooking.

Propane vehicles also cost more than their gasoline counterparts. However, fueling stations are fairly inexpensive. More than 350,000 vehicles, mostly in commercial fleets, are traveling the nation's highways under propane power.

Electricity

Electricity can be used to power vehicles. Electric vehicles (EVs) store electricity in batteries. EV batteries have a limited storage capacity and must be replenished by plugging the vehicle into a recharging unit. The electricity for recharging the batteries comes from a special electrical outlet in the home or business, or from distributed renewable sources such as solar or wind energy. EVs are called "zero-emission vehicles" because they release no harmful emissions into the air.

The cost of "refueling" an EV is minimal, but an EV certified to run on the highway is very expensive. Although newer battery technology shows promising developments, most EVs have a range of only 50-100 miles before recharging is needed.

Ethanol (E-85)

E-85 is a blend of 85 percent ethanol and 15 percent gasoline. Ethanol is an alcohol-based fuel produced by fermenting and distilling starch crops that have been converted into simple sugars. Typical feedstocks for this fuel include corn, barley and wheat. Ethanol also can be produced from "cellulosic biomass" such as trees and grasses. Most ethanol used in the United States today is made from corn.

E-85 can be used in "flex-fuel vehicles." These vehicles also can run on pure gasoline. Flex-fuel vehicles are very common in the United States today – many auto manufacturers now offer them and are part of their standard inventory. Unlike other AFVs, there is no additional cost for purchasing this vehicle. Because of this, and also because they can run on gasoline, they are a popular choice for fleet managers. Ethanol fuel is, however, sometimes more expensive than gasoline at the pump, although it is better for the environment. A problem in South Carolina is the lack of a supply of ethanol.

Biodiesel

Biodiesel is manufactured from vegetable oils or recycled restaurant greases. Biodiesel is safe, biodegradable and reduces serious air pollutants such as particulates, carbon monoxide, hydrocarbons and air toxins. Blends of 20 percent biodiesel with 80 percent petroleum diesel (B20) can be used in any diesel vehicle. It also can be used in its pure form (B100), but may require certain engine modifications to avoid maintenance and performance problems. French fry-fueled Fords may be in your future!

Alternative Fuel Use in S.C.

S.C. government offices began purchasing AFVs in 1996, as required by law. But while the Energy Policy Act required that governments buy AFVs, it did not demand that they use any alternative fuel. Since some AFVs can run on either an alternative fuel or regular gasoline, we have many AFVs but few alternative fueling sites. This is partly because of the high cost of installing the alternative fueling equipment.

This situation, however, is changing. Since 2000, South Carolina has developed three new AFV refueling sites with plans to develop more.

What kind of fuel do we use?

South Carolina's Office of Fleet Management has surveyed all government groups in the state to determine how many and what kind of AFVs they had. They also surveyed fuel providers to find out where our AFVs could go to refuel as state employees drive these vehicles to go about the state's business. This survey helped us discover that while we have about 2,500 AFVs operating in government fleets in South Carolina, we don't have much alternative fuel to put in them. This survey also helped us plan where to put alternative fuel stations in the future.

ETHANOL

Ninety-three percent of the AFVs operating in S.C. government fleets (about 2,300) are flex-fuel vehicles. Since these vehicles can run on either gasoline or E-85, most continue to be operated on gasoline.

Since 2001, two stations that dispense ethanol opened in South Carolina. United Energy Distributors, Inc., a private fuel supplier in Aiken opened the first public multi-alternative fuel station in the country in 2001. It sells E-85, in addition to propane and biodiesel. Anyone can buy fuel at this facility, making it the only publicly-accessible AFV refueling site in the state. The S.C. Department of Health and Environmental Control opened an E-85 refueling site in Columbia in 2002. This facility serves only vehicles owned by federal, state or local governments, not the public. There are more than 600 flex-fuel vehicles in government fleets in Columbia – this was their first access to E-85.

More ethanol facilities will open soon across the state. Many private citizens own flex-fuel vehicles and they will be able to take advantage of using this alternative fuel as well.

BIODIESEL

It's hard to count the number of vehicles using biodiesel because any diesel vehicle can use it. It is known, however, that the state fleet and some federal fleets in South Carolina have purchased biodiesel in bulk to use in their vehicles.

In addition, the S.C. Soybean Board is studying possibilities for building a biodiesel production facility in South Carolina. The state currently purchases biodiesel from Kentucky – making it more expensive to use.

CNG

In 2000, the Clean Cities Coalition worked closely with the Central Midlands Regional Transit Authority (RTA) as they made decisions regarding the fate of the City of Columbia's bus fleet. Thanks in part to their efforts, RTA decided to purchase seven new compressed natural gas (CNG) transit buses when they replaced the aging fleet in 2002. These buses reduce nitrogen dioxide and hydrocarbon emissions by 6,296 pounds per year over a ten-year period – resulting in a cleaner City of Columbia.

The Coalition and the S.C. Energy Office also worked to expand the capacity of Columbia's only CNG refueling station and to encourage other agencies to purchase CNG vehicles. Several city buses are fueled by natural gas as a result of this effort. In addition to the buses, the state fleet owns 70 CNG vehicles.

Local governments and utility companies in South Carolina own some CNG vehicles as well. In addition to fast-fill CNG stations in Columbia and York County, there are slow-fill stations in the cities of Rock Hill and Clemson, and in Greenville County.

PROPANE

There is more propane refueling infrastructure in the state than any of the other fuels because many propane companies use the fuel in their vehicles. But there are only 54 propane vehicles in the state fleet and only one station in South Carolina – the United Energy facility in Aiken – accepts the state's credit card.

Where do we go from here?

Alternative fuel use is very important for South Carolina and our country, because of dependence on imported oil and national air quality problems. There are many organizations in South Carolina that want to help increase the types and amount of alternative fuel used. The Palmetto State Clean Fuels Coalition is trying to organize all the groups and their efforts. This local group is part of a national effort called "Clean Cities" – coordinated by the U.S. Department of Energy.

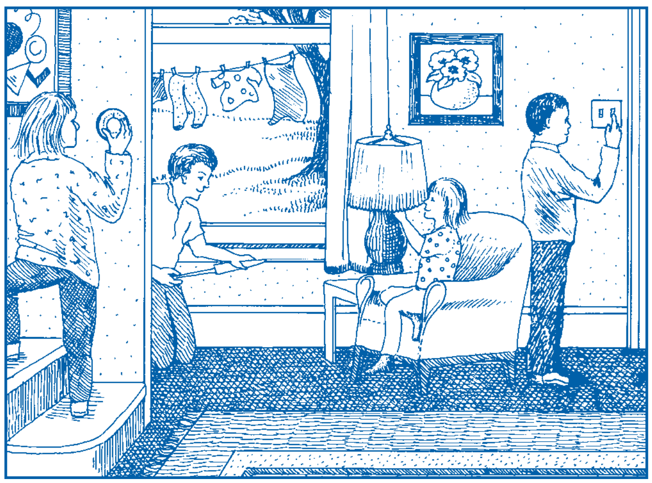
The Palmetto State Clean Fuels Coalition is committed to developing stronger networks of alternative fuel users in the state. It is reaching out to all existing organizations and programs that show a similar interest in improving the nation's energy security by lessening dependence on foreign oil and reducing emissions of ozone, carbon monoxide and particulate matters from motor vehicle usage.

Chapter 9

Conservation and Efficiency

Rethinking Energy Use

Today, people are rethinking the policy of unchecked energy use. Knowing that natural resources are limited, conservation and energy efficiency have become popular.



What is energy conservation? It involves finding ways to use less energy. Conservationists work hard to prevent waste.

Energy efficiency goes hand in hand with conservation. Its focus is on getting the maximum benefit from each energy resource consumed. For example, it involves determining the least costly method of generating electricity. It also means buying the appliance that can be operated using the least amount of power.

South Carolina is committed to energy conservation and energy efficiency. Because the state must import most of its energy, wise energy use is especially important.

Working Together To Conserve

Everyone has a role to play in promoting energy efficiency. And if everyone works together, the life of our energy resources can be extended. While energy needs to be used efficiently in all sectors, there are three areas where everyone can make a difference — at home, at school and in transportation. When reading the conservation ideas presented here, think about the energy practices used at school and home.

Home Energy Efficiency

About one-fifth of all energy use takes place in homes. In South Carolina, most residential energy use goes to heating and cooling homes. This is followed by water heating, appliance use and lighting.

Many specific activities have been identified to reduce home energy use. Some of these cost money in the beginning but will generally pay for themselves over time. All of them involve a commitment of effort. Before trying them, talk with the rest of your family.

HEATING AND COOLING CONSERVATION

- Adjusting your thermostat is the best and least costly conservation measure. Try to get used to lower temperatures in winter and warmer temperatures in summer. See if your family will agree to lower the thermostat to 68 degrees in winter and raise it to 78 degrees in summer. Your family will save five to six percent on their utility bill.

- Locate the thermometer on an inside wall that's not near sunlight, vents or lamps. This will provide an accurate reading of the temperature.

- Dress appropriately. Keeping comfortable has much to do with how well you insulate or ventilate your own body. Try loose fitting clothing, open collars and open weaves for hot weather, layers of clothes and closed collars for colder weather.

- In cold weather, use more blankets or a down comforter.

- In the winter months, leave shades, blinds, and curtains open on sunny days to make use of the sun's heat. Close them on cloudy days to prevent heat loss. Reverse the process in the summer.

- Close the fireplace damper when it's not in use to prevent heat loss.

- Don't cover the top of heating or cooling vents with knick-knacks, furniture or belongings. This makes it necessary to use more energy. For the same reason, don't hide vents behind draperies.

- Help cool weather come inside. The more cool air that comes inside, especially at night, the better. Experiment to see which windows and doors to open or close to create the best flow of cool air throughout your home.

- Let hot air out. Encourage your parents to open the upper vents in your attic and make sure no lower vents are blocked.

- Since hot air rises, open the upper part of double hung sash windows and, in a two story house, the upstairs windows.

- Let breezes inside. If windows are blocked by shrubs or tree foliage, the bushes might need pruning.

- An exhaust fan in a window can push out warm air and pull in cool air. A window fan is more economical to run than an air conditioner. A window fan in an apartment or one-story house should be in a window on the warmest side; in a two-story house, put it in an upstairs window.

- Use ceiling fans if they are in your home. In the winter, run them in reverse to circulate warm air. In the summer, run them to create a downward breeze.

- If you have central air conditioning, don't close off unused rooms or shut off vents. Rather than saving energy, this makes the system work harder.

- It may be easier to move yourself into a nice, warm sunny room on a cold day, say to do homework or eat a snack, than it is to move that free solar heat to a cooler part of your home. Upholstered furniture, like a big armchair or sofa, will soak up the heat very nicely when placed in a sunny spot.

- Encourage your family to use storm doors and windows. Make sure the storm doors are fastened tightly and the doors are closed properly.

- When it's time to paint the outside of your home, suggest using light colors. Since South Carolina's climate tends to be warm, light-colored paint is a good choice because it reflects sunlight.

WATER HEATING CONSERVATION

- Use hot water wisely. Don't let water run. Don't use hot water if cold or lukewarm will do. For example, run the garbage disposal with cool water, not warm.

- Try to get in the habit of taking a shower instead of a bath. Showers typically use less hot water. Water-saving shower heads will typically pay for themselves in a few months.

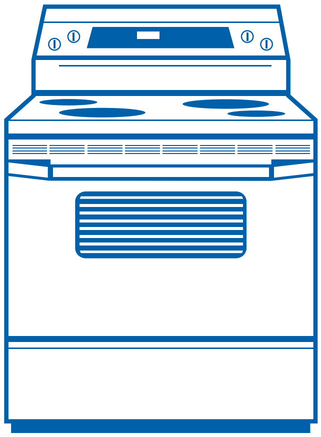
- Watch and listen for leaky faucets. A two-cent washer can save hundreds of gallons of water in a year.

- Wash clothes in cold water when possible.

APPLIANCE CONSERVATION

- Cut back on the amount of water used for boiling eggs, potatoes and other foods. The more water used, the more energy is needed to make it boil or simmer.

- Use pots that are the same size as a burner so that heat doesn't escape.



- Make sure pot and pan lids fit tightly. This keeps heat inside. It also makes the food cook faster.

- If you have a toaster oven or electric frying pan, use it. They use half the electricity of an electric oven.

- Microwaves energy. Microwaves not only cook food in one-fourth the time, they use 30 to 70 percent less electricity.

- Avoid peeking in the oven. It not only makes a soufflé fall, it drops the oven's temperature 25-50°F every time it's opened.

- Periodically vacuum the condenser coils on the back or bottom of your refrigerator. (Unplug it first!) Dust acts as an insulator on the cables, making the refrigerator work harder.

- Refrigerators and freezers work best when they are full. But items need to have space between them so air can circulate.

- Don't place hot or uncovered foods in the refrigerator. It takes increased energy to cool hot foods. Uncovered foods will lose moisture to the refrigerator.

- Test to make sure the refrigerator and freezer seals are working by placing a dollar bill lengthwise along the edge and closing the door. If the dollar falls, your appliance needs to have the seal replaced. An airtight seal helps the appliance work efficiently.

- Utility companies suggest that you put petroleum jelly along refrigerator and freezer seals to make them last longer.

- Defrosting frozen foods in the refrigerator helps the refrigerator stay cool. It also uses less energy than microwave defrosting and, in the case of Thanksgiving turkey, is safer than defrosting on a counter top where bacteria might grow.

- A freezer with more than 1/4 inch of ice needs to be defrosted to save energy.

- Always wait until there is a full load to run the dishwasher, washer or dryer. But full doesn't mean overloaded. Overloading wastes energy and rarely gets the job done. On a sunny day, think about using the solar dryer — the clothes line.

- Turn off the TV, radio or video game when they're not in use.

- If you have an "instant on" TV, part of the TV is actually on all the time. One way to turn this type of TV off is to plug it into a socket that is controlled by a light switch and to use that light switch when you turn off the set.

- Encourage your family to pay attention to the yellow energy tags and labels when buying new appliances. Comparing tags is an excellent way to help your family make an energy-wise choice. The higher the efficiency level, the greater the savings as the appliance is used.

LIGHTING CONSERVATION

- Use lower watt bulbs in stairwells, closets and areas that don't require reading light.

- To make a room brighter, use one bulb of high wattage. For example, one 100 watt bulb uses less energy than two separate 50-watt bulbs.

- Use energy-saver bulbs. These give as much light as conventional bulbs but use less energy.

- Encourage your family to use compact fluorescent lamps (CFLs). These bulbs are comparatively expensive to buy, but are long-lasting and extremely economical over the long run. CFLs last up to 10 times longer than incandescent light bulbs, use 25 percent of the energy and produce 90 percent less heat while producing more light.

- Suggest using light-colored lamp shades. They reflect 50 percent more light than dark shades.

- Try placing a lamp in a corner of a room. Here it has two surfaces to reflect off of rather than just one wall.

School Conservation

Because schools are buildings, many of the same ideas can be used. Here are some specific thoughts:

- If your classroom has its own thermostat, make sure that heaters and air conditioners are turned off (or lowered if the outside temperature is extreme) at the end of the day.

- Make sure drapes or shades are closed at night to insulate the room.

- Turn off lights when leaving for recess (if everyone leaves the room), during special activities when the class is on a field trip or assembly, and at the end of the day.

- Check for broken windows, torn or damaged weather-stripping and caulking and leaky faucets. Report any detected problems to the maintenance staff.

- Check for drafts using a homemade "draft detector." A piece of tissue, parchment, wax paper or plastic wrap can be taped to the bottom of a hanger so that it hangs freely. When this detection device is hung from a window sill or held by a door or near vents and outlets, the hanging material will wave if a draft is present. Again, any problems should be reported to maintenance.

- Track utility meter readings. Based on this information, school staff can decide if more drastic conservation measures are needed.

- If your school doesn't already have a recycling program, start one. Your county or city government can help secure the needed bins and any other supplies. Separating newspapers, glass, plastics and aluminum cans from our other garbage can easily become second nature. Recycling is an fun way to both save energy and protect the environment.

- Think of other things within your school to recycle like paper (doing two-sided copying), books, art supplies, paper clips and more.

- Encourage your school to be "precyclers." This means buying school supplies and cafeteria products that are packaged in recycled paper or are made of recyclable materials. Recycling, like energy conservation, is a state of mind.

Transportation Conservation

Most of the energy used in the transportation sector comes from petroleum. Because petroleum is a non-renewable resource, saving energy is particularly important.

There are three basic conservation measures to remember:

1. **Increase the number of people riding in a car at one time.** When going to a school function, a sports meet, a party or any other

event, organize a group to ride there together. By riding together, fewer cars need to be driven. Fewer cars on the road means less energy is used. Likewise, encourage your parents to ride to work or meetings in carpools.

2. **Combine trips.** Plan to run all errands after school or work in a systematic fashion.

3. **Switch to more energy-efficient transportation.** Public transportation saves energy. People who ride buses, subways and trains save energy by leaving their cars at home. Any time it's possible take public transportation instead of being driven, think about doing so. Best of all, ride your bike or walk to nearby places.

Conclusion

Be it in cars, in schools or at home, energy conservation is something everyone can all do. While one person alone makes only a small difference, a whole nation of conservationists makes a huge difference.

In South Carolina, if everyone could conserve 10 percent of the energy used, residents could save more than $800 million to spend on other things and it would help protect the environment. The responsibility to reduce our energy resources rests within all of us.

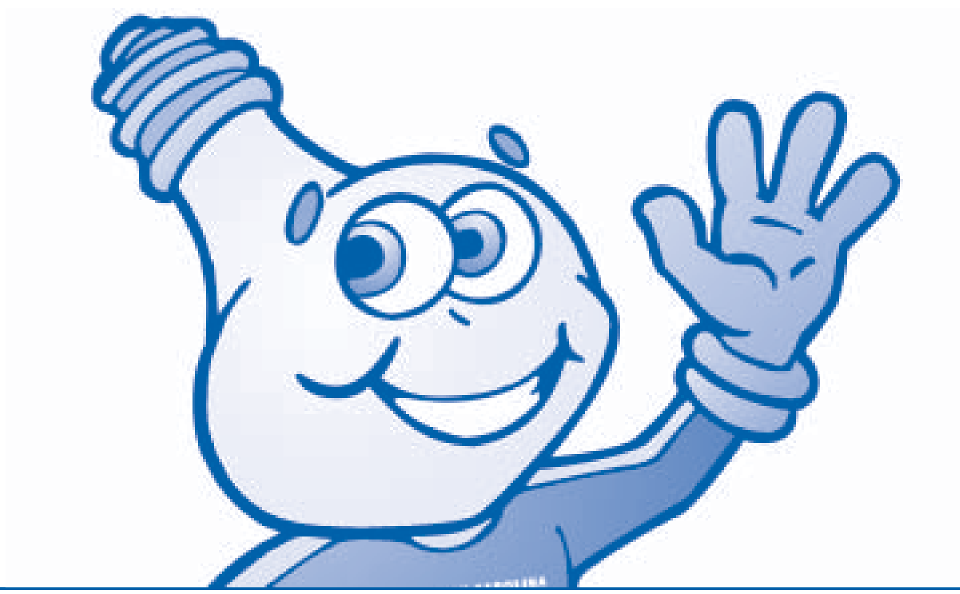
An Energy Challenge

Across the nation, schools generally spend 34 percent of their maintenance and operations budget on energy. This accounts for about 7.5 to 8 percent of a school district's total budget. Since energy rates are set, the only way to reduce this budget item is to save energy. The idea for an energy challenge began in Colorado in 1984. That year, students throughout the state surveyed their schools to see where energy was being used and how it could be saved. As a direct result of this project, energy costs for Colorado schools decreased 18 percent.

There's no question that South Carolina students can be as effective conservationists as Colorado students. So take up the challenge at your school. Work with your principal and your student government to do an energy audit of your school. Here are some things you'll want to look at:

- What are the energy bills like now? What have they been over the past few years? Keep track of meter readings.
- What type of heating, cooling and water heating equipment are used? Where are they located?
- Are there any drafts, damaged weather-stripping or leaky faucets?
- How and where is the building insulated?
- Is fluorescent lighting used?
- What conservation practices do teaching, support and maintenance staff follow? Are lights turned off when leaving a room? Are thermostats lowered at night? How is temperature controlled?
- Do the classrooms have shades or blinds?
- Do landscaping and color choices of paint and window treatments promote use of passive solar energy?
- What types of appliances are used in the cafeteria, the media center and offices?

This is just a beginning point for your investigation.
Take the challenge and save your school energy... and money.

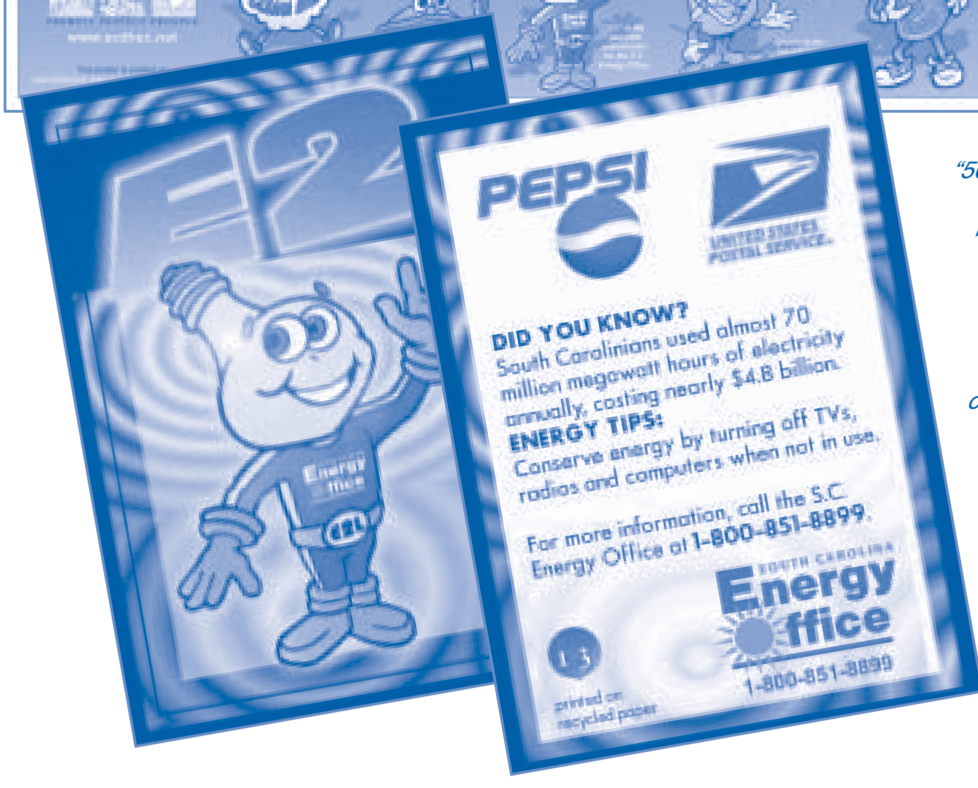


Energy 2 Learn Resources

The S.C. Energy Office and DHEC's Office of Solid Waste Reduction and Recycling provide the following resource materials to teachers, schools and the public at no cost. To receive copies, call **1-800-768-7348** or visit **www.scdhec.gov/recycle**.

Pictured is the "What is Energy?" poster (right) and bookmark (above).

More E2L Resources



"50 Ways to Protect South Carolina's Environment" (above) is a poster featuring tips to improve air quality, conserve water, protect coastal resources, recycle and conserve energy.

A series of environmental trading cards also is available. The 20-card set includes one featuring E2, the S.C. Energy Office's goodwill ambassador, and includes other fun energy facts.

Remember, these materials are available to teachers, schools and the public at no cost. To receive copies, call ***1-800-768-7348*** *or visit* ***www.scdhec.gov/recycle****.*